1959

Twenty-third Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Eastern Soil and Water Management Research Branch
Soil and Water Conservation Research Division,
and
Grain and Forage Insects Research Branch
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

For Administrative Use Only

THE LABORATORY STAFF

H. L. Carnahan	Agronomist in Charge
Lois L. Smith	Secretary

Project Leaders

H. L. Carnahan	Breeding and Grass Cytogenetics
J. H. Graham	Plant Pathology
A. W. Hovin	Legume Cytogenetics
R. C. Newton	Entomology
C. L. Rhykerd	Soils
V. G. Sprague	Physiology and Microclimatology
J. T. Sullivan	Plant Chemistry

Assistants

C. F. Gross	Soils
Helen D. Hill	Cytogenetics
G. A. Motter	Agronomy and Physiology
E. S. Titlar	Plant Chemistry
K. E. Zeiders	Plant Pathology

Part-Time Assistants

Donald Burdick	Plant Chemistry
Gerald E. Carlson	Physiology
T. G. Phillips (New Hampshire)	Chemistry

COLLABORATORS

B. A. Brown, Connecticut	R. P. Murphy, New York
C. S. Brown, Maine	C. E. Phillips, Delaware
W. G. Colby, Massachusetts	G. G. Pohlman, West Virginia
H. B. Couch, Pennsylvania	M. A. Sprague, New Jersey
A. M. Decker, Jr., Maryland	R. C. Wakefield, Rhode Island
H. A. Keener, New Hampshire	G. M. Wood, Vermont

H. R. Fortmann, Penna. - Representative of Northeastern Directors

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PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the twenty-third in the series, was prepared by and is intended primarily for use of personnel engaged in forage research in the twelve Northeastern States. It contains a brief summary of progress during 1959. Included are research reports from project leaders at the U. S. Regional Pasture Research Laboratory, from the six northeast forage crops technical committees, from research workers at the state experiment stations and from personnel of the Forage and Range Research Branch at Beltsville, Maryland.

Collaborators assembled and edited materials from their respective stations, chairmen of regional technical committees supplied copies of their annual reports, and project leaders and section heads at the Pasture Laboratory and Beltsville, respectively, prepared descriptions of their research.

There were a number of personnel changes at the Pasture Research Laboratory during the year. Mr. Gerald Carlson was appointed as a part-time assistant in plant physiology. Mr. Carlson recently completed his M.S. degree in agronomy at Iowa State University and will work toward the Ph.D. at Pennsylvania State University. Mrs. Mary L. Denison, assistant in chemistry, has been replaced by Mr. Edgar S. Titlar, a recent graduate of Penn State. Mr. Robert I. Corl, one of our greenhouse and field assistants, resigned to sell insurance and was replaced by Mr. Harold J. Donley. Dr. Charles L. Rhykerd, soils project leader, returned to his alma mater, Purdue, and it is expected that this vacancy will be filled at an early date. The following statement was adopted in principle by the Northeastern Directors.

Suggested Responsibilities and Duties of Collaborators

From the standpoint of operational procedure the following functions of collaborators are suggested:

1. The collaborator at each station shall be responsible for encouraging preparation of suitable reports by the various workers at his station for the Annual Report of Pasture Research in the Northeastern United States. He shall assemble these reports for his station and forward them to the Officer in Charge of the Laboratory by April 1 each year.

2. The collaborator at each station is appointed by the director to represent all interests of the station and state. To comply with this intent it will be his responsibility to arrange such meetings/or conferences with his colleagues as are necessary for him to be adequately informed about needs and problems in all the special areas of research so that he is truly representing the station and state and not merely his own specialty.

3. Each collaborator should keep his director informed of the progress of the Laboratory program. He should supply his director with a copy of the minutes of each collaborators' conference.

4. The collaborators should assume responsibility for determining research needs of the region. They should then determine a tentative priority rating and be in a position to suggest whether they might best be worked on by individual states, by the Laboratory, or as cooperative ventures.

   To perform this charge effectively, it will be necessary for the collaborator group to be thoroughly conversant with the regional research projects and all of the research going on at the individual stations. It will also be essential to be familiar with the organizational structure of the Laboratory and personnel specializations. It is appropriate for the collaborators to recommend additions to the professional staff when such additions are deemed necessary for the Laboratory to carry out the suggested program. The final decision on employment of personnel will be made by ARS in accordance with Item 5 of the Memorandum of Agreement.

5. The collaborators together with appropriate representatives from the participating ARS branches and the Officer in Charge of the Laboratory should periodically review the program being carried on at the Laboratory. It would seem appropriate for this review to be conducted within the following framework:

   a. Is the program of research of the Laboratory designed to answer high priority problems relative to grassland agriculture in the Northeastern States? The limitations of budget, equipment, facilities and personnel will be recognized in such an evaluation.

   b. What research or additional activities might advantageously be indicated or expanded with realignment of existing funds or if new funds become available? What priority should these have? What effect will these recommendations have on current research activities?

Method of Operation of Collaborators

The collaborators are to represent the states of the Northeast Region. (Expenses for travel to the collaborators meetings are provided through the Laboratory budget). In order that they may function as a unit, a chairman and secretary should be elected from within the group. It is suggested that the secretary succeed to the chairmanship and that a new secretary be elected at the conclusion of the collaborators annual meeting. If no meeting is held during a year, no change in officers would occur.

The collaborators should determine how best to proceed in their review. It may be advisable to consider all facets of the laboratory program in general group meetings. Or it may be best for the chairman to appoint sub-committees for each of several areas. As an example the following areas might well be considered:

1. Soils and fertilization
2. Management, plant physiology, and climatology

3. Breeding and genetics
4. Plant pathology and entomology
5. Utilization, animal nutrition, biochemistry
6. Mechanization, agricultural engineering, economics, miscellaneous

Laboratory personnel and ARS research leaders will participate fully in all meetings in the evaluation of the Laboratory program. This will be equally true in developing recommendations for both the immediate future and for long-range plans.

The directors will assume responsibility for providing a group of collaborators with balanced representation of the pertinent subject matter areas.

The proposed schedule of appointments that follows accomplishes the following:

1. Provides continuity within the collaborator group in that only three collaborators are replaced each year.

2. Provides balance among the specialities since there are two representatives indicated for each area of specialization.

3. Provides for continuity within disciplines since in any given year the three collaborators being replaced come from three different areas of specialization.

4. Provides for maximum solicitation of interest from all disciplines since over the six appointment periods covered by the schedule, provision is made for representation from each subject matter specialty during one four-year period for each state.

5. Provides for stimulation of interest and opportunity of suggestion from groups not currently included in the laboratory program.

Suggested Schedule of Collaborator Appointments
with Recommended Area of Specialization for Each Appointee

State	Year Collaborator to be Appointed (Suggested Area of Specialization in Brackets)					
Conn.	1959 (3)	1963 (4)	1967 (5)	1971 (6)	1975 (1)	1979 (2)
Del.	1959 (1)	1963 (2)	1967 (3)	1971 (4)	1975 (5)	1979 (6)
Me.	1960 (6)	1964 (1)	1968 (2)	1972 (3)	1976 (4)	1980 (5)
Md.	1961 (4)	1965 (5)	1969 (6)	1973 (1)	1977 (2)	1981 (3)
Mass.	1960 (2)	1964 (3)	1968 (4)	1972 (5)	1976 (6)	1980 (1)
N. H.	1962 (6)	1966 (1)	1970 (2)	1974 (3)	1978 (4)	1982 (5)
N. J.	1961 (1)	1965 (2)	1969 (3)	1973 (4)	1977 (5)	1981 (6)
N. Y.	1960 (5)	1964 (6)	1968 (1)	1972 (2)	1976 (3)	1980 (4)
Pa.	1962 (3)	1966 (4)	1970 (5)	1974 (6)	1978 (1)	1982 (2)
R. I.	1962 (5)	1966 (6)	1970 (1)	1974 (2)	1978 (3)	1982 (4)
Vt.	1961 (2)	1965 (3)	1969 (4)	1973 (5)	1977 (6)	1981 (1)
W. Va.	1959 (4)	1963 (5)	1967 (6)	1971 (1)	1975 (2)	1979 (3)

Key to Areas of Specialization:

1 - Soils and fertilization

2 - Management, plant physiology, and climatology

3 - Breeding and genetics

4 - Plant pathology and entomology

5 - Utilization, animal nutrition, biochemistry

6 - Mechanization, agricultural engineering, economics, miscellaneous

RESEARCH AT THE PASTURE LABORATORY

GENETICS, ENTOMOLOGY AND PATHOLOGY

Alfalfa

Selection for Disease Resistance

Single crosses were made among the clones selected for persistence at Connecticut in 1958 (1958 Annual Report, page 4). Sufficient seed of some 90 crosses was obtained so that seed can be made available to Mr. B. A. Brown for persistence evaluation at the Connecticut Station. The same crosses are being evaluated for seedling vigor and leafhopper resistance at the Pasture Laboratory.

The program aimed at developing materials with resistance to foliar pathogens was continued. During the winter of 1958-1959, 123 selections were selfed and intercrossed to provide over 12,000 seedlings. These were inoculated successively with Pseudopeziza and Ascochyta in the seedling stage and reduced to 3,220. These plants along with susceptible checks were rated for disease reaction twice in the field with 291 vigorous plants being selected for resistance to the two leaf diseases, crown rots and Cercospora which was severe in 1959. These plants were later screened for Pseudopeziza and Ascochyta in the laboratory and reduced to 117 elite plants. None of these selected plants had any Pseudopeziza in the final test. These selections are being selfed and sibbed to further concentrate resistance and evaluate homozygosity for resistance.

These materials probably represent the best source of resistance to foliar pathogens in combination with winter hardiness and reasonable agronomic desirability that is available.

The 91 crosses formed by a 14-clone diallel were evaluated for Ascochyta and Pseudoplea reaction. For Ascochyta, mean performance of clones in crosses from most resistant to most susceptible was: C319, C608, C641, C640, C611, C625, C629, C630, N.C. 4, C307, C902, C303, C318, and C616. Ranking from most resistant to most susceptible for Pseudoplea was: C319, C318, C307, C616, C303, C629, C625, C611, N.C. 4, C640, C630, C902, C641, and C608.

A Rapid Method for Screening Alfalfa for Resistance to Corynebacterium insidiosum

The petiole method of inoculating alfalfa with the bacterial wilt organism continues to look good (1958 Annual Report, page 32). Latest results of inoculation of 75 eight-week-old seedlings (after three weeks) are as follows:

	Percent		
	Sus.	Intermed.	Resist.
DuPuits	84	11	5
Narragansett	71	25	4
Buffalo	25	35	40
Vernal	26	21	53
Sus. line	89	8	3

Procedure: Use young bacterial colonies preferably on beef-lactose agar (Colonies are purple on this medium). Dip fine, hollow glass needle in the colony and pierce the petiole at the junction of the two side leaflets. Inoculate younger leaves near top of seedling or succulent shoot. Within two or three weeks (according to amount of sunshine) leaves on susceptible plants will become yellow. Inoculate three petioles per plant. Seedlings can be inoculated as soon as the petiole is large enough so that it will not be severed or damaged by the needle. At this stage seedlings are six to eight weeks old with 6 to 10 trifoliate leaves.

Selections for Spittlebug and Potato Leafhopper Resistance in Alfalfa

Two plants of each of 51 root-spreading alfalfa clones were examined for plant resistance to spittlebugs by counting the nymphs per mass, masses per stem and masses per plant. Two clones with low counts were selected for crossing with alfalfas selected for leafhopper and disease resistance. These same root-spreading alfalfas were likewise rated on their degree of yellowing as an indication of potato leafhopper resistance.

With 51 clones the correlation between spittle masses per stem and nymphs per stem in 1959 was +0.67**. Using 1958 and 1959 data on the 30 clones

evaluated both years, the interannual correlations for both masses per stem and nymphs per stem were non-significant. One clone, however, had lowest masses per stem and nymphs per stem of all clones tested in each year.

Several flats planted to Buffalo and Culver alfalfa were exposed to potato leafhopper injury in the greenhouse during March and April 1959 and selections were made from those withstanding injury and possessing the best growth habits. The selections were moved to the field where they were exposed to disease and leafhopper damage under field conditions and where they were screened on their ability to withstand the combined disease-leafhopper injury. The final selections are being crossed with plants selected for resistance to crown rot, leafspot, and spittlebugs.

Survey for Alfalfa Weevil in Pennsylvania

The alfalfa weevil was found in Cambria, Indiana, Washington, Clearfield, Bradford, Lackawanna, Susquehanna, Greene, Westmoreland and Montour Counties, Pennsylvania for the first time this year. It first appeared in Centre County, Pennsylvania in 1957. Only moderate larval and adult populations and insignificant injury occurred in Centre County fields in 1959.

Combining Ability in Alfalfa Single Crosses

From the 14-clone diallel (1958 Annual Report, page 6) the data on seedling vigor and fall growth habit in the year of establishment at the Pasture Laboratory, Indiana, Minnesota, Nebraska and North Carolina have been prepared for publication in the Agronomy Journal.

In 1959, yield, spring vigor, rate of recovery following clipping and fall dormancy were recorded. The components of variance analysis for these characters has not been completed. It is evident, however, that the crosses exhibiting extreme fall dormancy are generally low in yield. It is also clear that fall dormancy in the year of establishment is highly correlated with fall dormancy in the next year. Likewise, for this material, those crosses with most seedling vigor (tallest seedlings) appear to recover most rapidly following clipping.

Varietal Hybrids and Mixtures

Yields were taken on this test (1958 Annual Report, page 6) in the first harvest year. For the mean of 15 comparisons the so-called variety crosses averaged 4.53 tons of 12% moisture hay in contrast to 4.49 tons for the parents grown in individual plots. In 11 comparisons variety crosses averaged 4.47 tons, mixtures (in pairs) of the parental varieties averaged 4.48 tons, parent varieties in unmixed plots averaged 4.44 tons while the average of the higher yielding parent variety in each cross was 4.82. In no case did a variety cross yield significantly different than the mean of its parent varieties grown separately or as a mixture of 2 varieties. On the other hand, the higher yielding parent variety of a varietal cross significantly out-yielded the variety cross in a number of instances. Results from other stations participating in this cooperative test will also be of interest.

The Genetic Model used for Alfalfa Diallels

The 14-clone diallel analyzed for combining ability (1958 Annual Report, page 6) required a genetic model which was based on several assumptions. One assumption was that reciprocal crosses gave the same results. This assumption could not be tested in the field planting in 1958 because reciprocals were not kept separate.

A test for reciprocal differences was made with 6 pairs of possible single crosses among 4 of the 14 clones. A randomized block design was used with 3 replications. Seeds placed in flats were thinned to 16 seedlings per reciprocal cross. The 2 characters measured were petiole erectness of the first trifoliolate leaf of 3-week-old seedlings and height of 6-week-old seedlings. Respectively, 4 and 3 crosses showed significant reciprocal differences for these 2 characters. Because the seeds used in the test were harvested from insect-pollinated plants another test will be repeated with hand-crossed seed harvested from emasculated plants to determine whether selfing has contributed to reciprocal differences.

Another assumption in the model was that percent cross fertilization to produce the 91 single crosses was uniformly high and the low amount of selfed seed resulting in established seedlings did not bias the results. A preliminary study was conducted to evaluate self-fertility of the 14 parent clones under 2 environments. In the greenhouse in January, number of seeds per 100 pollinated florets ranged from 171.7 to 8.4. Less seed was obtained in the field in July and the ranking differed from that in the greenhouse. Inbred progenies of C318 and C902 had high seedling vigor in contrast to inbred progenies of C608 and C630. Comparisons will be made between seedling vigor of inbred progenies and that of crosses of the same parents.

Inheritance of Qualitative Traits

Inheritance studies of a yellow leaf-character were continued but genotypes cannot be assigned until further segregating generations have been obtained. Because of uncertainties regarding the classification of the different phenotypes a preliminary study attempted to determine the amount of chlorophyll in fresh leaf samples of representative phenotypes. A spectrophotometric method was used and the results demonstrated that yellow plants had approximately 1/3 the amount of chlorophyll of normal green plants. The difference in total chlorophyll between homozygous and heterozygous green was probably within the limits of the experimental error. Total chlorophyll varied proportionally to the a/b ratio for green material, but with one exception, the reverse relationship held for 3 yellow phenotypes.

Inbred progenies of a normal green clone segregated 2.34 normal to 1 albino (lethal) seedlings. It appears that the albino and yellow leaf characters are controlled by different genes.

A cross between 2 plants with approximately 75 percent aborted pollen resulted in progenies with complete pollen sterility. Seeds were produced on these plants when crossed to normal, and genetic studies of this material are in progress.

Supernumerary leaflets were observed on 3 clones. Inbred progenies of one clone were classified for this character which required nearly 4 months before being expressed on some plants. This character, therefore, may not be very useful in genetic studies.

Inbreeding Alfalfa

The test comparing clones of selected inbreds with parents was damaged by ice to the extent that it was discontinued in 1959.

Breeding and Genetics of Root-spreading Alfalfas

Diallel crosses were made among the 6 best root-spreading clones selected at this station during the last few years. These 15 crosses along with Rambler and the 6 parent clones were established in 10 replicates of 20 seedlings per cross per replicate and then overseeded with timothy in early September. Percentage of seedlings expressing root-spreading in the year of transplanting varied from 2 to 13.5 for the crosses and was zero for Rambler.

Seedling vigor data were taken on individual seedlings prior to transplanting. Mean seedling vigor of seedlings of a cross showing root-spreading in the first year was consistently a little better than that for all seedlings of a cross.

This test is designed to provide evidence of the relative magnitudes of additive and non-additive gene action on root-spreading, to obtain a measure of possible correlations between seedling vigor and other characters, and to provide source material for selecting root-spreading types that are better adapted to the Northeast. It is contemplated that differential cutting frequencies will be imposed on the test to obtain some information on the effects of managements on root-spreading expression and development as well as information on the interaction, genotypes x environments.

Saponins and Coumestrol in Alfalfas

This station is participating in cooperative tests designed to obtain information on possible differences among alfalfa varieties in saponin and coumestrol contents and on the possible effects of different environments on quantitative development of these constituents in alfalfa. Samples were collected in 1959 for saponin analysis.

Ladino and Other Clovers

Interspecific Hybridization and Cytogenetics in Clover

In addition to the interspecific crosses mentioned in 1958 Annual Report, page 9, unsuccessful attempts were made among 12 clover species bringing the total to 4,256 crosses. More extensive crosses were made between Ball clover (Trifolium nigrescens Viv.) and Ladino clover (T. repens L.). Interspecific hybrids were obtained on 4 accessions of Ball clover but embryo culture technique was required for seedling establishment, using the method described in the 1958 Annual Report, page 9. In one reciprocal cross hybrids were obtained without the aid of embryo culture. The results suggested that differences in interspecific cross-compatibility may be genetically controlled and that the 2 species are closely related.

Meiosis was analyzed in T. repens x T. nigrescens hybrids with 24 somatic chromosomes. Three hybrids averaged 4.2 univalents at diakinesis with a range from 2 to 8. The remaining chromosomes were interpreted to be associated as bivalents except for 3 possible trivalents out of 14 cells.

Smeared and sectioned materials were analyzed at metaphase I in 10 hybrids but neither method permitted an evaluation of chromosome stickiness. A maximum of 8 univalents were observed in 500 cells examined. Although lagging chromosomes were present in second division of meiosis, the quartet stage was normal with no micronuclei. Stainable pollen from 4 samples of each of 10 hybrids averaged 7 percent and ranged from 1 to 16 percent. The hybrids were sterile when intercrossed, but seeds were obtained in backcrosses to Ladino clover.

Several explanations of the meiotic behavior of triploid T. repens x T. nigrescens chromosomes are possible but the most likely suggestion is that pairing occurred between the nigrescens genome and one or both of the 2 repens genomes. Because meiosis was found to be regular in T. repens extensive residual homology is unlikely between the 2 apparently diploidized subgenomes.

Inheritance of Leaf Markings

Linkage relationships between red-V and white-V leaf marking in Ladino clover is being studied further because definite conclusions cannot be drawn from the present materials.

Colchicine and Somatic Mutation

Studies on the ability of colchicine to induce somatic mutation in Ladino clover were described (1958 Annual Report, pages 9 and 10). Similar studies were made with alfalfa in 1959. As was the case with Ladino clover no morphological changes were noted on the treated alfalfa shoots during the growing season. It was concluded that colchicine at the concentrations used (range 0.05-0.4 percent) did not induce visible somatic mutations in these materials.

Factors Affecting Persistence of Ladino White Clover

A field experiment set up in April 1956 to determine some of the factors involved in stand depletion of Ladino white clover (1958 Annual Report, page 10) was terminated in September 1959. Results are given below. Vigor notes only (1-10 most vigorous) were taken in 1956 and 1957 since stands were good in all plots. In 1958 and 1959, the percent ground cover by the clover was estimated (1-10 with 10 = 100%). Each year four readings of three replications were made during the growing season. The chemicals

applied were a soil fumigant before seeding and various insecticides and fungicides during the seasons. The "no-chemical" plots consist of a control plot and three plots to which Pseudoplea and/or virus were added. We were not able to contain the diseases so all plots were averaged.

Treatments	Vigor 1956	Vigor 1957	Ground cover 1958	Ground cover 1959
Early cut				
Chemicals	5	9	8	7
No chemicals	6	6	4	3
Early cut and flowers removed				
Chemicals	5	9	8	7
No chemicals	6	7	4	2
Late cut				
Chemicals	4	9	7	6
No chemicals	6	6	4	2

A manuscript has been prepared for publication.

Attempt to Increase Persistence in Red Clover

Forty-five individual plants were selected from second cycle plots established in 1957 (1956 Annual Report, page 8). A disproportionate number of survivors occurred in plots resulting from crosses of plants previously selected for persistence in contrast to named varieties. Surviving plants selected may serve a useful purpose in breeding for persistence. These selections are being increased vegetatively and plots will be established near bee hives for seed increase.

Internal Breakdown in Crowns of Red Clover

An internal breakdown (IB) of the crown of red clover was found in all fields observed from Maine to Virginia. Necrosis occurs first as a dark, watery area in the pith of the crown when plants are approximately 3 months old. As plants mature, incidence of IB increases and affected areas enlarge and later become corky and dry. In the greenhouse the incidence of IB increased from 23 percent of the plants at the end of 12 weeks to 72 percent at the end of 41 weeks. No organism was consistently associated with IB and as yet the cause is not known. Results have been published.

In more recent studies all F_2 seedlings of IB x IB plants develop internal breakdown within five months. Many black dots developed on the leaves of these plants.

Insect-Pathogen Relationships in Red Clover and Ladino White Clover

An experiment conducted in the greenhouse in 1957 and 1958 using potted red clover plants with caged clover root curculios; clover root borers; and mechanical injury (cutting roots) and adding Fusarium to the soil showed that these factors produced growth differences and demonstrated an injury-root rot association. A similar experiment conducted in the greenhouse in 1958 and also in 1959 using potted Ladino white clover, clover root curculios, mechanical injury (cutting roots) and adding Fusarium demonstrated a relationship between Sitona hispidula injury and the incidence of root rot in Ladino white clover.

A study was made to determine why red clover stands die in their second year by digging and examining roots each week during the seedling and second year for root growth, weevil feeding, associated and independent root rot, internal breakdown and virus. The data indicated that weevil damage, rot, and internal breakdown are major factors in the second year decline of stands. An almost simultaneous interaction of these factors arrested root growth in June and by October some two-thirds of the plants in the experimental field were killed.

Seasonal History of Sitonids and Calomycterus setarius in Legumes

The larvae of Sitona hispidula, S. flavescens, and Calomycterus setarius occurred together in the soil of legume fields where they fed externally on roots. Populations were highest in Ladino white clover, intermediate in red clover, and lowest in alfalfa reaching peak numbers from May to mid-June, and then transforming to adults. C. setarius matured first, followed in 5 to 7 days by S. flavescens, and in 10 to 20 days by S. hispidula. C. setarius became sexually mature about mid-July, S. flavescens followed about August 1st and S. hispidula started reaching sexual maturity after the first week in September. Adults of C. setarius died in the fall, those of S. flavescens and S. hispidula overwintered as adults. C. setarius larvae were successfully reared on potted red clover to induce injury. About ten percent of the small rootlets showed feeding marks, some main roots were scoured, but the deep gouging characteristic of the Sitona was absent.

The Pseudoplea Diseases of Legumes

Physiological and pathogenicity studies of Pseudoplea were expanded to include more isolates and more species of Pseudoplea on hosts other than alfalfa and Ladino white clover. Tests included optimum temperatures for fungus growth, ascospore development, ascospore discharge, and ascospore germination; sporulation in darkness and light; and host range studies. Data from these studies further substantiate the separation of the following species: Pseudoplea trifolii, P. briosiana, P. gaeumannii, P. americana, and Pleosphaerulina argentensis.

Pathology and Morphology of Some Leguminous and Related Species of Stemphylium

This study (1958 Annual Report, page 14) has been terminated and a manuscript submitted for publication.

Orchardgrass

Survey of Insects on Orchardgrass

A periodic survey of orchardgrass showed the most abundant insects to be grasshoppers, crickets, the plant bugs Trigonotylus ruficornis, and Leptopterna dolabratus, the leafhoppers Graminella nigrifrons, Draeculocephala sp., Macrosteles fascifrons, Ambysellus curtisii, Endria inimica, the meadow spittlebug, Philaenus leucophthalmus, and the immature stage of a sawfly. Japanese beetle larvae were the principal soil insects.

Breeding Improved Dactylis glomerata

Important differences were observed in 1959 both among and within late maturing sources established in 1958 (1958 Annual Report, page 14). Several introductions from Japan were severely injured by the winter. Polycrosses of MIV-17, XLI-8 and MXII-5 were most winter hardy. Polycrosses of these same three clones had the lowest percentage (about 5%) of non-heading plants of the 19 sources included in the test. Mid-May vigor of plants that later failed to head was generally less than that for "headers" within a particular source. The fact that some non-headers had above average vigor suggests that vigorous types that will not head under our environmental conditions may be selected.

Pa. 55-L1, L2 and L3 synthetics had respective mean June anthesis dates of 12.7, 8.0 and 10.4. These synthetics had high percentages of non-headers, i.e. 63.5, 48.0 and 47.5, respectively. Two of these synthetics, Pa. 55-L1 and L2 were outstanding in resistance to purple leafspot and streak. The morphologically distinct Japanese introductions were found to have 2n = 28 chromosomes.

Eighty-three plants were selected for establishment in a polycross nursery for further observation.

Male Sterility in Orchardgrass

Backcross-type progenies i.e. (MS x MF)MF were established in the field in 1959 from 13 crosses. Approximately 3/8 of the plants that headed were male-sterile. In two crosses which involved male-sterile parents with 28 chromosomes, ratios of F:S approximated 1:1. In addition, all 10 male-sterile plants selected from these crosses were found to possess 2n = 28 chromosomes in their root tips. Thus it appears that the inheritance of male-sterility may now be pursued in agronomically desirable plants uncomplicated by aneuploidy.

Bromegrass

Selection for Disease Resistance

The 365 seedlings selected in 1958 for resistance to Helminthosporium bromi were reduced to 167 on the basis of reaction to Stagonospora bromi. The 167 selections were broken into 3 propagules each and established in a replicated nursery in 1959. These plants were inoculated in the field and on the basis of these diseases as well as Rhyncosporium and Rhizoctonia the number was reduced to 110. Disease notes will be taken again in 1960. More promising clones will be selfed and allowed to open-pollinate to provide materials for another cycle of selection and more extensive evaluation.

Stagonospora bromi on Bromus inermis

Limited studies on S. bromi are being continued (1958 Annual Report, page 17). Physiological studies included the determination of optimum temperatures for mycelial growth (20° - 25° C.), spore production (20° - 25° C.), spore germination (25° C.), and disease development (near 26° C.). Morphologically, the fungus agrees with previous reports in the literature.

Scolecotrichum graminis, Causal Agent of Brown Stripe of Grasses

Studies have been initiated to develop techniques for the production of conidia in culture and for the production of epiphytotics in the greenhouse. To date a single sporulating culture (isolated from orchardgrass) has been developed.

Tall Meadow Fescue

Meiosis and Genome Homologies

Frequencies of AI bridges and/or fragments and of micronuclei in quartets were determined in 79 S_1 plants derived from tall fescue clone #247 that was obtained from Oregon. The parent clone was characterized by a mean of 10.5 percent AI cells with bridges and/or fragments and 11% of the quartets with micronuclei.

Mean percent of AI cells with irregularities in the 79 S_1 plants was 18.7 with a range of 1 to 70 percent. Mean percent of quartets with micronuclei in the S_1's was 25.8 with a range from 7 to 54 percent. The correlation coefficient between these two cytological characters in the 79 S_1's was +0.37**. Only 4 of the 79 S_1 plants had as low a frequency of micronuclei in the quartets as the non-inbred parent. Twenty of the S_1 plants were as low as the parent in frequency of AI irregularities.

These results are in agreement with results with orchardgrass and rye where meiotic irregularities have progressively increased with inbreeding.

It is possible that regular meiosis in tall fescue and perhaps other allogamous species is dependent upon a heterozygous homeostatic genetic mechanism.

Most raw allopolyploids derived from interspecific hybrids, including those involving tall fescue, are meiotically quite unstable. The information derived from the present study suggests that at least a part of such instability may be related to the consequent homozygosity attained in colchicine-doubled alloploids.

Selection for Fertility in Derivatives of Intergeneric Hybrids

Ice sheets and other winter injury practically eliminated all of the triploid and tetraploid progenies of the triploid hybrids (L. perenne (2x) x F. elatior (4x)). Open-pollination seed had been harvested in 1958 from two 28-chromosome derivatives and this was used to establish a new nursery of 535 plants in 1959. These will be checked for fertility and agronomic characters in 1960.

Similarly O.P. seed harvested from vigorous 3x derivatives of the original intergeneric triploids was sown in flats and sod plugs from these flats were set in the field to permit natural selection. Seed heads will be harvested for another cycle of selection for fertility.

A few O.P. progenies were obtained from the 35-chromosome (triploid F_1 x F. arundinacea) which had been treated with colchicine. Chromosome number determinations on 10 of these plants indicate 2 with 28, 5 with 42, and 3 with 49 chromosomes. The 49-chromosome plants have softer foliage than tall fescue and will be watched carefully for possible fertility. Remnant "seed" harvested from the colchicine-treated 35-chromosome hybrids will be planted to see if additional derivatives may be obtained.

Nearly 400 backcross seedlings of the type ((colchicine-doubled L. perenne (2x) x F. elatior (4x) x F. arundinacea) x F. arundinacea will be established in the field in 1960.

Meiotic studies on F_1 hybrids made at Kentucky, i.e. L. perenne and L. multiflorum x F. arundinacea indicate that Lolium chromosomes pair with Festuca chromosomes and that Festuca chromosomes of the haploid set also interpair. There were generally more observable univalents at MI in L. multiflorum hybrids but fewer laggards at AI than in the L. perenne hybrids.

Review Paper on Genetics and Cytogenetics of Grasses

We are continuing the review of current literature on this topic and incorporating materials in the review paper which should reach the top of the list for publication in The Botanical Review within a year. We will appreciate having called to our attention any recent theses containing information that should be included in this review.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Grasses

(In cooperation with D. G. Routley; New Hampshire Station)

At present, carbohydrate studies are confined to (1) the properties and composition of hemicelluloses and (2) the composition of isolated cellulose preparations from grasses (1958 Annual Report, page 20).

Results of stepwise hydrolysis of holocellulose with very dilute acid were reported last year. Examination of the data obtained by the analysis of sugars and oligosaccharides released by the acid have led to the following conclusions: The hemicelluloses of grasses have a considerably branched structure with a core of pure xylan and side chains of considerable length containing arabinose, galactose, rhamnose, and uronic acids as well as xylose. Glucose is not combined in the same molecules with other sugars but occurs in a glucan which resembles the other hemicelluloses in solubility.

The ready breakdown of a considerable part of the hemicellulose by very dilute acid suggests that losses have occurred during previous attempts to isolate hemicelluloses, and yields that have been reported were low. This was demonstrated by treating holocellulose with hot water and examining the dissolved constituents. Four successive treatments of holocellulose with boiling water, each for 24 hours, gave extracts which were acid, pH 3.8, and contained considerable amounts of free sugars and some partially hydrolyzed hemicelluloses. For example, from 10 grams orchardgrass holocellulose were obtained 189 mgs. free arabinose and 29 mgs. free xylose, most of it during the first extraction. The hemicellulose fragments contained 240 mgs. sugar of which the greater part was xylose. These results indicate that during hot water extraction acidity is produced which causes hydrolysis of a hemicellulose and the losses that have occurred may have been due to hydrolysis rather than to simple solubilization. These losses were considerably reduced when buffer solutions were used instead of water.

The preparation of the holocellulose from the dried grass also entails losses which were investigated. Chlorite holocelluloses were prepared by the previously adopted method. At each step of the procedure samples were withdrawn and analyzed in order that the places where the losses occurred could be located. It was found that some losses of each carbohydrate constituent occurred with every step. These losses may have been from hemicelluloses or from other carbohydrates containing similar components. For example, only about 50 percent of the galactose, 50 percent of the arabinose, and 80 percent of the xylose present in the original grass were found to be present in the holocellulose. The remainder was removed by the action of water, pepsin, ammonium oxalate solution, or chlorite. Autoclaving with water alone resulted in high losses, particularly of arabinose and galactose.

Cellulose is the most abundant constituent of forage plants and when moderately digestible furnishes the greatest part of the energy of forages. Variability in the digestibility of cellulose does not seem to be accounted for by any single factor, such as lignification, and a study of the properties of cellulose seems justified. Celluloses commonly known as "Crampton and Maynard cellulose", and "Norman and Jenkins cellulose" were prepared from orchardgrass. The former was found to contain, in addition to the main glucose constituent, some xylose which was quite resistant to removal. In the latter cellulose were found galactose, arabinose, and considerable xylose, in addition to glucose. A complete hydrolysis of any cellulose, with quantitative recovery of the component sugars, has not yet been obtained.

Native cellulose contains two areas, crystalline and noncrystalline. The last form is believed to be more susceptible to the action of hydrolytic agents and might be more susceptible to the digestive process. Preliminary investigations with Crampton and Maynard cellulose disclosed that the proportions of cellulose in the noncrystalline form was in timothy 14, bromegrass 14, alfalfa 25, red clover 28, alsike clover 32, and Ladino clover 35 percent.

A new procedure for the determination of cellulose in forages is under study. It consists of heating a sample of the forage with ethanolamine, delignifying with sodium hypochlorite and sodium sulfite, and finally extracting with sodium hydroxide. The residue is termed "ethanolamine cellulose". The percentages of this substance found in various forages were lower than those of the two celluloses mentioned above.

Lignin of Forage Plants

The lignin content is closely related to nutritive value. A number of properties of lignin have been studied. Exhaustive extraction in bulk of forages by benzene-alcohol mixture caused a loss of lignin. The solvent had developed an acidity to which lignin, in the presence of alcohol, is susceptible to degradation. Autoclaving with water caused a loss in apparent lignin and heating with ammonium oxalate solution caused apparent increases. Freezing fresh forages followed by drying without heat caused unusually high apparent lignin contents. These properties may affect the apparent amount of lignin found on analysis.

Nitrogen is present in all lignin preparations, and was found to vary from 1.9 to 3.6 percent. It was not removable by pepsin and by this criterion is not considered to be protein nitrogen.

Lignin is readily decomposed to a high degree by heating with sodium chlorite or chlorine in acid solution and is also susceptible to other oxidizing agents. Low-lignin products of forage obtained by such methods have higher

digestion values to ruminants than untreated forages. Because of the treatment in water medium much of the water-soluble constituents, which amount to 15 to 30 percent of the forage and contain substances of high digestibility have been lost. Experiments were carried out, in cooperation with T. V. Hershberger of the Pennsylvania Station, to determine whether delignification could be carried out without loss of the soluble constituents. Chlorine dioxide gas was passed through a glass tube containing air-dry forage. No loss occurred in the quantity of sample and the moisture content was not significantly altered. The apparent lignin content was found to be decreased considerably, more than half in some cases. The coefficient of digestibility of the cellulose, determined by the in vitro technique, had increased considerably, 50 percent in grass and with the proper dosage of chlorine dioxide more than 100 percent in wheat straw.

Plant Climate

Plant climate studies (1957 Annual Report, page 20 and 1958 Annual Report, page 25) were continued. Air temperatures during 1959 were from 2 to 4 degrees above normal April to September inclusive and were 2, 3, and 4 degrees below normal in March, November, and January, respectively. In February, October and December, temperatures were near normal.

Precipitation was 2 or 3 inches above normal during July, August and October and favored growth while 2 inches in November moistened soil before freezing. The above-normal temperatures in May and June coincided with precipitation almost 2 inches below normal resulting in noticeable soil moisture deficiencies. These were not replenished at the 16-inch depth under alfalfa until late August.

Last spring air temperatures of 32° occurred April 13 in Maryland and May 25 in Vermont. First 32° in the fall occurred September 18 in Vermont, Rhode Island, New York and Pennsylvania, and on October 19 in New Hampshire, Connecticut, West Virginia, New Jersey and possibly November 2 in Maryland. The number of summer days between low temperatures of 32° ranged from 116 in Vermont to 202 in Maryland.

Soil temperatures at several depths from 2 inches to 16 inches beneath a grass sod were reported by seven stations. Warmest soils occurred during July with the temperatures in Maryland the highest and those in Rhode Island 10° cooler. In Vermont, Connecticut and Pennsylvania, conditions were intermediate and approximately the same in these three states.

Soil moisture measurements were taken in Pennsylvania and indicated a dry period in June with increasing moisture in July and early August. Predominately cloudy months included January, March, April, July, October, November and December. Most clear days occurred in February, May, June, August and September.

Lowest average soil temperatures under a bluegrass sod occurred the first half of January. Temperatures at all depths (2, 4, 8, and 16 inches) were 32° or slightly above during the last of March. Average soil temperatures in February were lowest at the 8-inch depth where the soil remained frozen longer than at the others. Snow cover was small and variable.

Spring observations on 5-year stands of alfalfa indicated severe heaving had occurred. Alfalfa and Kentucky bluegrass started to turn green March 28.

Climate Studies (In Cooperation with Nine State Stations in the Northeast - NE-29)

Reports of daily air and soil temperatures, precipitation, dew, cloudiness, etc. were submitted monthly, and prepared summary statements of all states were sent to each cooperating station.

Precipitation was below normal in all states during May and September and was generally above N during October and November.

Air temperatures were below normal in all states during January and in half or more of the states in February, March and November. Temperatures were above normal during April, May, August, September and December.

Temperature and Plant Growth

Studies in plant growth chambers measuring effects of constant and alternating air and soil temperatures of 60° and 70° F. on germination and growth (1957 Annual Report, pages 20-21; 1958 Annual Report, pages 25-26) were continued using mean temperatures of 50° and 80° F.

Total seedling emergence of the different species was determined for both constant and alternating temperatures at mean temperatures of 50° and 80° F. The rates of emergence under these conditions were also measured.

Percent emergence of Kentucky bluegrass was much greater under alternating temperatures than under constant both at 50° and 80° means. Emergence of other species was similar under alternating and constant temperatures but with alternating temperatures it was slightly better for white clover at 50°, and for birdsfoot trefoil at 80°.

Six weeks after emergence the plants were harvested and their dry weights were determined. Using the weights obtained under constant soil and air temperatures as the base, the relative weights of growth under the other combinations of alternating air and/or soil temperatures were calculated.

Species responded quite differently relative to constant and alternating temperatures of the air and soil. At a mean temperature of 80° F. the best growth of white clover occurred when the air temperature was constant and soil temperatures alternated daily between 70°-90°. Poorest growth was obtained when air temperatures alternated and soil temperatures remained constant at 80°. Under 50-degree mean temperatures greatest growth was made when both the air and soil temperatures alternated 40°-60°.

The relative weights, when grasses and legumes are combined, for each of the mean temperatures studied, 50°, 60°, 70° and 80° F., indicate that at 60° total growth is greatest and that at 60° mean alternating temperature of either air or soil is better than constant. However at 80° alternating air temperatures decreased growth and constant air and soil temperatures are most favorable.

Responses of Red Clover to Phosphate Fertilizer at Four Intensities of Artificial Light

Increasing general use is being made of growth chambers to provide controlled conditions of temperature, humidity, and radiation. Under controlled environments, specific soil fertility, nutrient solution, plant defoliation, and pathological treatments are being measured. Much effort is generally made to provide artificial light for chambers with as high a footcandle intensity as possible.

Fluorescent lamps have been primarily used because installation is relatively simple and footcandle intensities provided by them are twice that of filament lamps requiring equal electrical power. The "cool white" fluorescent lamp provides the highest footcandle intensity and generally is most widely used, but because its emission of light in the red region of the spectrum is limited several 60-watt filament lamps are frequently mounted between the "cool white" lamps.

In this experiment the lamps used in larger walk-in chambers were "cool white" power-groove type while those used in the smaller Laboratory chambers included special fluorescent lamps with a phosphor that emitted a high proportion of light in the red end of the spectrum but gave a lower footcandle intensity.

In growth chambers it is impractical to provide light with the sunlight quality and intensity of 10,000 footcandles on a clear day. The minimum light intensities required to measure plant responses to various plant treatments or soil fertilities is not known. To obtain specific information on the intensity required for such reliable measurements of the effects of temperature and fertility treatments on growth, a fertility experiment was repeated in which light at an intensity of 500 f.c. had been supplied by "warm white" fluorescent lamps. In this re-run, five light intensities ranging from 250 to 1,225 f.c. were used to measure effects of intensity in determining growth responses of red clover at different temperatures to the placement of different amounts of phosphate fertilizer on a soil that tested "no available phosphorous".

As was expected total growth increased under higher light intensities and where phosphorous or temperature were not limiting factors. The primary objective of this work was to determine whether similar relative responses to temperatures, placements, and rates were obtained at both higher and lower light intensities.

While similar results were obtained at all intensities, growth was small at 250 f.c. and the relative error in plant measurements was larger. Thus the use of an intensity of 500 to 750 f.c. is better and there seemed no need to use 1000 f.c. or more for studies using red clover, and particularly when the red-orange producing phosphor is used. Statistical analyses of the data indicated that all primary factors and their first-order interactions exceeded the .01 level of significance.

The results of the same fertility treatments conducted in the greenhouse under natural light were similar to those obtained under artificial light in the chambers.

Legume and Grass Seedling Establishment

Observations made in April 1959 were made on the survival of alfalfa and Ladino clover seeded in 1958 (1958 Annual Report, page 27-28). Considerable heaving occurred in both alfalfa and Ladino clover. Total emergence in the early seedings of 1958 were not as large as some later seedings but survival of early seeded plants was twice as great as those seeded later. The survival of alfalfa was much better than that of Ladino clover. In early seedings larger root systems and crowns were noted.

In 1959 birdsfoot trefoil and three grasses; orchardgrass, bromegrass and reed canarygrass were included in the emergence study of alfalfa and Ladino clover and birdsfoot trefoil. Five seedings were made at approximately 3-week intervals from April 15 to July 16. Seedings were made in soil of moderate fertility with adequate organic matter at 1/4 inch depth in four 1-foot rows, six inches apart, without a companion crop. Fifty seeds of

alfalfa, orchardgrass, bromegrass and reed canarygrass and 100 seeds of Ladino clover and birdsfoot trefoil were used in replicate rows.

The frequency and amount of precipitation was recorded until maximum emergence occurred; precipitation relationship included one or two days prior to seeding. The average daily maximum, minimum and mean temperatures 1-inch deep in bare soil were recorded from seeding time until maximum emergence occurred.

At intervals of two to five days, observations and counts were made of the number of visible plants in each row where a seeding had been made. The rate of emergence for the several species was quite different. Alfalfa emerged rapidly while Ladino clover and birdsfoot trefoil were slower. Grasses were generally slower than legumes.

Alfalfa and Ladino clover seedling stands in 1959 were slightly better than those in 1958. Precipitation during April was normal and in July was above normal, while in May and June it was below normal. Temperatures for these months were from two to four degrees above normal. Higher temperatures in April and May with adequate moisture near the time of seeding Ladino clover probably accounts for slightly better stands. With higher temperatures and adequate moisture, maximum emergence occurred sooner.

Growth of Ladino Clover Seedlings in Association with Orchardgrass

The inhibition of growth of Ladino white clover seedlings by orchardgrass grown in the same nutrient solution, using gravel cultures in the greenhouse, received further study (1958 Annual Report, page 28-29). These trials indicated that greater inhibition of Ladino clover by the orchardgrass occurred as the orchardgrass became older and produced more roots and top growth. There was also an indication that cutting the orchardgrass increased growth of the clover. On the basis of these indications the experiment was repeated with changes wherein orchardgrass of three ages (46, 25, and 4 days after starting from tillers) were used at the time the clover seedlings were planted. One group of Ladino seedlings were grown without contact with orchardgrass.

Additional treatments used with all ages of grass involved a complete change of nutrients each week compared to those not changed but where N, P, and K levels were maintained. Also in each of the above treatments grass was (1) clipped monthly and (2) not clipped.

Harvest of the clover grown in all treatments was made 50 days after the clover was started. Observations and measurements made on each clover plant in each pot of the four replicates per treatment indicated that clover growth was poorer when orchardgrass was larger and that cutting the grass monthly increased growth of clover.

In general, changing the nutrient weekly increased the vigor of the clover and the numbers of stolons produced. It is particularly evident that older and larger grass inhibited growth of clover much more than younger grass. Also it is evident that cutting the grass increased growth of the clover.

Luxury consumption of potash from the nutrient solution was great and further trials are planned to measure growth responses of clover at different potash levels where orchardgrass is not present.

Growth of Red Clover in Nutrient Solutions Containing Various Levels of Phosphorus

Pennscott red clover was grown in nutrient solutions containing 0.05, 0.10, 0.40, 1.60 and 6.40 ppm phosphorus. A constant-flow technique was devised in order to maintain the phosphorus levels within rather narrow limits. It appears that a concentration of 0.10 ppm phosphorus is sufficient for good root growth. However, a concentration of 0.40 ppm phosphorus was necessary for high yields of top growth.

Effect of Temperature and Phosphorus on the Growth of Sorghum Seedlings

(In cooperation with E. F. Sullivan, Pa. Agric. Expt. Sta.)

A study was conducted in temperature controlled growth chambers to determine the effect of constant temperatures of 60, 70, 80, and 90° F. and 5 phosphorus fertilization levels of 0, 50, 100, 200 and 400 pounds of P_2O_5 per acre on the growth rate of sorghum seedlings. Piper sudangrass, RS-501 grain sorghum and FS-1a forage sorghum were tested under artificial light of 1000 f.c. during a 15-1/2 hour day for 6 weeks.

Constant temperatures of 60 and 70° F. were too cool for rapid top and root growth of sorghum seedlings. Highest top and root yields of Piper sudangrass and RS-501 grain sorghum were obtained at 80° F. while FS-1a forage sorghum produced highest top and root yields at 90° F. Top growth of Piper sudangrass and RS-501 grain sorghum was approximately the same at 90 as at 80° F. However, root growth of these 2 varieties was significantly lower at 90° F. than at 80° F.

Top and root yields were increased with each increment of phosphorus fertilization except at 60° F. However, at 70° F., temperature limited maximum plant response to phosphorus fertilization.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING

Leader: R. W. Kleis, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, A.E.R.D. and S.E.S.D., A.R.S. (U.S.D.A.).

RESULTS:

A. Harvesting

The behavior of tractor tires in legume harvesting received intensive study. Comparisons of performance of new and "old" tires as it affects crop damage and recovery indicated significantly greater damage by old tires and that both effect significant damage compared to control plots. Drawbar loads from 0 to 1500 pounds reflected no significant differences. This raises questions of effects of weight as compared to slippage for future investigation. Earlier studies on slippage and compaction (terminated and reported 1958) revealed damage to grass during harvesting was greater from heavy loading than from slippage. Better controlled studies are set up for further study by establishment of new pure stands of alfalfa and red clover.

Extensive studies of various hay conditioning units have been conducted by several Stations during the course of this project. Because these investigations are complementary in nature and were conducted under NE-13, a comprehensive regional bulletin is being prepared on "Hay Conditioning". Further work on the flail harvester confirmed previous findings of high field losses (17% to 35%) and expedited field curing with this mower-conditioner unit. Studies indicate no significant increases in drying rate caused by hay fluffing (tedding). Investigations of windrower-conditioners indicate that the beneficial effects of conditioning are nullified by immediate windrowing and that windrowing immediately at cutting without conditioning severely retards curing.

Basic studies of mower cutting action, energy requirements, plant properties, and interrelationship of these factors are continuing under controlled, well-instrumented laboratory conditions. Studies of effect of knife speed indicate no significant difference of energy required between 80 and 211 inches per minute. Tests to determine the modulus of elasticity in the elastic range for dry alfalfa showed an average of 4.23×10^6 psi. Testing equipment and recording instrumentation have been assembled for studying energy requirements for impact cutting of forage.

Detailed studies of field harvesting losses in baling and chopping were initiated. Losses as caused at various machine components (pick up, cutting unit, bale chamber, and discharge) were isolated effectively with baling operations but considerable difficulty was experienced in collecting and retaining losses from choppers. Improved procedures for evaluating chopper losses are being given attention. Preliminary data indicate baler losses of 1.1% to 9.6% at pick up and .38% to 1.52% at discharge.

Studies continued for comparing silage harvesting methods; direct cutting and wilting. Exclusive of hauling time, total times required for harvesting and storing were 1.33 man hours per ton (D.M.) for direct cut and 1.06 man hours per ton for the wilting method.

Moisture distribution in hay during field curing was studied on alfalfa and clover. Preliminary results indicate that conditioned leaves and stems dry at similar rates while unconditioned stems react very slowly to favorable drying conditions.

B. Processing

A 32-kilowatt infrared drying oven has been developed and used for investigating use of radiant energy in forage drying. Preliminary observations indicate the lack of residual energy after discontinuing radiation; leaf drying rates of 2 to 4 times that of alfalfa and clover stems and a direct relationship of drying rate to moisture content.

The tiered duct fan drier was successfully used on a 43-ton charge of 35% - 40% moisture hay in short randomly piled bales. Air flow requirements are higher for this system (30 cfm/sq. ft. floor area) because of air channeling.

Drying system investigations were continued. Cost studies involving 152 tons through the Greek Cross system gave an average fuel cost of $2.86 per ton. A total of 24 tests were made on the experimental wagon drying system to determine optimum recirculation temperatures and times. The average fuel cost in this system was $5.12 per ton. Inadequacies in design of controls presently used become apparent and modifications are being studied. Length of cut affects drying. Splitting the stems longitudinally and laying them open approximately doubled the drying rate.

Wagon drying studies indicated no significant differences in drying rates of randomly piled short bales and stacked 30-inch bales. Over-drying of top layers in the down-draft system was less with random piling than with stacking. With 40% initial moisture content, a thermal efficiency of 28.7% was obtained and fuel cost was about $3.00 per ton.

Development and testing of the experimental continuous drier for baled hay was continued. In addition to the two chambers used previously, two chambers were designed and used in this season's work in which air flow was through the 14" dimension of the bale in contrast to air flow through the 18" dimension of the original chambers. Four tests this last season

indicate a maximum moisture content of 35% for satisfactory performance of this system. Faster drying and more uniform drying pattern resulted from air flow through the 14" dimension. Preliminary estimates of optimum amount of air to be recirculated were 25% to 40%, in this system.

Basic investigations under closely controlled conditions were continued on the relationships of factors involved in drying efficiency and system behavior. This work permits precise analysis and is establishing mathematical definitions of the various relationships associated with product drying. Specifically, this season's work permits the definition of the depth of the drying zone and time required for an increment layer to dry in terms of air temperature and air flow rate (other variables remaining constant).

Work was initiated this year on moisture transfer rates in forage curing. Instrumentation and control apparatus are being developed for small sample laboratory studies. Crops from greenhouses will permit year-round activity on this project.

Pelleting and wafering are receiving attention at several Stations. One study is designed to determine moisture levels for safe storage, how to attain and maintain those levels and the requirements for handling mechanically without excessive breakage. Preliminary work on a non-extrusion hay pelleting device indicates:

1. Pelleting energy required varies linearly with moisture content.
2. Energy required is not affected by length of cut.
3. Long hay pellets are more durable than those formed from chopped hay.

Laboratory studies found extrusion force reduced to 60% by lining the die with a teflon carrying enamel. The rapid deterioration of the lining has led to the fabrication of a solid teflon die.

C. Storage

Controlled condition investigations of pneumatic handling of chopped forage continued. This season's work provides much needed information on relationships between conveying velocities, conveying rates, friction losses, moisture content and fan speeds. Points were established for various families of curves. Work on silage blowers has resulted in a metering unit to control the discharge from wagon to feeder table. Preliminary tests of the silorator blower indicate a non-conveying blower efficiency of 34% at 6.5 pressure. A conveying rate of 6½ tons per hour gave conveying efficiencies of 2½ to 3½%. The investigation of physical properties and storage requirements for intermediate moisture content forage was continued and intensified during this second year. Eleven different storage units were studied in 60 different tests under controlled laboratory conditions. Preliminary data indicate that conventional silos (except wood) may be effectively sealed for successful storage of haylage.

Conveying and elevating equipment is being studied and/or developed. A new type conveyor has been developed for placing chopped hay in storage as well as removal for feeding. This double chain unit with tined flights distributes or collects hay with the under side and is designed for vertical adjustment as well as lateral traverse. Leaf shattering and low capacity appear to be serious drawbacks of this unit. Further studies of the tube conveyor indicate a limit of 4-5 inches lateral depth for corn silage and a desired depth of 10 inches for chopped hay. These factors indicate the need for a variable thickness unit which is considered impractical. A new system of three conveyor units was developed for conveying bales, from vehicle to drier, from drier to storage, from vehicle to storage and for distribution in storage. The design and fabrication of an auger type mow unloader for chopped hay have been completed. This unit has been installed in a mow and preliminary tests conducted. The unit is designed for elevated storages and automatic operation with timed control from stable area. Another conveyor is being investigated to semi-mechanize the removal of chopped hay from storage. This unit pivots about the floor opening on a single tire to eliminate carrying of hay to the chute.

Short bale handling and storing were investigated. Random pile short (18" or less) bales gave similar volumetric efficiency in storage to stacked conventional bales. For such short bales, vehicle side racks of at least 6 feet are required and higher elevator flights (5" or 6") are necessary.

A mechanical unloader developed for bulk grain is working very successfully in an experimental feeding installation. It utilizes a vertical center auger to maintain a discharge channel from the upper surface which is swept by a suspended chain and scraper unit.

The box silo studies and development have been terminated with the preparation of a bulletin.

D. Feeding

In continued work on self-feeder silos the baffle sliding pin combination has been replaced by a double baffle system. This new simplified system of vertical movement control is being studied during the current feeding season after preliminary indications of merit last season. In a second silo rotating pins have been partially replaced by rotating wheels to reduce layer thickness and approach continuous flow. Modifications have also been made in the center caps to reduce resistance to silage flow.

The development of the conveyor feeding system for stanchion barns is continuing. The automatic silo unloader lowering device performed very satisfactorily during the 1958-59 season. Attempts to mechanically dismember bales without excessive shattering and to deliver the hay to a metering device proved unsuccessful. A more promising approach is currently being pursued in which hydraulically operated tines separate varying amounts of hay as called for by a programmer.

Manual and mechanical unloading of silage were subjected to time studies. Manual - 46 to 160 pounds/minute; Top Unloader - 100 pounds/minute; and Bottom Unloader - 75 pounds/minute. Manual feeding (700 lbs) required 45 minutes additional time per feeding while the mechanical unit did it concurrently with unloading. Revision of the experimental silo unloader incorporated the principle of slow movement to avoid accelerating power. While problems still exist with this unit, progress indicates the feasibility of the original objective: To unload silage at the rate of 200 lbs. per minute with 1 HP or less.

USEFULNESS OF FINDINGS:

Information obtained on basic physical properties of forage will allow more deliberate and logical design of machines and processes.

Information obtained on energy requirements and cutting action of forage units will be of direct benefit to designers and the manufacturers.

Evaluation of various conditioners, tedders, and flail harvesters is of immediate value in advising farm operators and designers.

Understanding the effects of harvesting machine traffic on seedings will lead to improved management equipment for minimizing damage.

Field harvesting loss information on harvesting systems will contribute to system evaluation and improvement of components.

Studies of basic relationships involved in forage drying will provide for meaningful definition of problems and accurate establishment of design parameters.

Applied development of drying methods and systems based upon defined principles, promises to relieve the enormous losses currently resulting from climatic and mechanical deterrents to quality hay.

Progress in development of mechanical elevating and conveying units promises even greater efficiency, simplicity, and saving of manual effort.

Basic studies of behavior of materials in pneumatic conveyors may well lead to improvement of the currently used inefficient units which have the singular advantage of simplicity.

Mow distributors provide for uniform placement of hay in storage without manual effort for greater volumetric and drying efficiency.

Development of self-feeding procedures will contribute directly to the incorporation of this principle of efficient operation into livestock enterprises.

Mechanical feeding of cattle in stanchions combines the operating efficiency of loose housing with the attractions of tradition of stanchion barns.

Meters, grain bin unloaders and other systems of quantity control increase the practicability of mechanical feeding in controlled feeding enterprises.

Mechanical mow unloading systems provide the link between mechanized harvesting and mechanical feeding for complete mechanization of hay handling.

Considerable progress in the development of systems for handling chopped hay compared to much relatively fruitless effort on baled hay handling points up the inherent limitations of batch (bale) handling.

Harvesting and storing forage at an intermediate moisture content offers promise of combining the desirable features of both hay and silage while avoiding the inherent problems of each.

WORK PLANNED FOR NEXT YEAR:

The 1960 harvest season is to be used to put finishing touches on current activities insofar as possible rather than to inaugurate new work. There is great need and opportunity for the continuation of a regional effort in the area of physical systems for forage production, handling, and/or utilization. Specific project activity intentions are as follows.

Continuation of evaluation of forage cutting energy requirements at Connecticut.

Further evaluation of field losses of components of choppers and balers over a range of wind, moisture and crop conditions at Massachusetts.

Basic forage drying relationships will receive further attention at Maine, New Jersey, and Pennsylvania.

Effects of machine weight and wheel slippage on legume recovery will continue at New Hampshire with particular attention to contact pressures.

Flail-type harvesters are to be compared further with other harvesting and conditioning units with respect to losses and drying rates at New York.

Development and analysis of drying systems will continue at two stations; wagon drying systems at New Jersey, and continuous bale drying and batch drying at West Virginia.

Maryland will conduct additional work to further define and project families of curves expressing relationships of key variables in pneumatic conveying. New Jersey plans further analysis of blower test data and development of a test stand for obtaining data on the characteristics of forage flow in pneumatic systems.

New Jersey also plans further study with development of silage flow control devices in vertical self-feeding silos.

Further development of the mow unloader with particular attention to increasing capacity is planned at Massachusetts. New York plans to install and test their mow conveyor.

Vermont and Pennsylvania plan further activity on pelleting.

Continuation of efforts to improve the design and efficiency of silo unloaders is planned at West Virginia. This station also plans to complete its development and evaluation of the multiple purpose wagon.

Massachusetts studies of physical properties and storage requirements of haylage are to continue.

Vermont plans further work on baled hay metering for stanchion feeding and continued development of the grain bin unloading unit.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED TESTING PROCEDURES.

Leader: J. L. Newcomer, Chairman, Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Geneva and Ithaca), Pennsylvania, Rhode Island Agricultural Experiment Stations, F.C.R.B. and S.E.S.D., A.R.S., U.S.D.A.

RESULTS:

Evaluations were made on the broadcast field plantings made in 1957 at Md. and N. Y. and in 1958 at Md., N. Y., Pa., and R. I. to evaluate expression of plants in the extremes of the region and to compare these values with greenhouse plantings. Attempts were also made to determine varietal purity and identity. Sources of variability in some of the broadcast plots have made it difficult to see and measure differences. Thus valid conclusions could not be drawn from some field plantings. At the Geneva, N. Y. locations, where the sources of variability were kept at a minimum, preliminary results indicate that the lots tested were quite similar to the check lots. In 1957 plots at N. Y. all except three lots tested appeared to be true to the varietal characteristics. These lots of Vernal alfalfa contained 5, 7, and 16% respectively of intermediate plants. In the 1958 plots, the seed stocks were true to varietal characteristics except for two stocks of Vernal, one of which contained 18% intermediate plants and 2% non-dormant plants and the other 14% intermediate plants.

In 1959 uniform space plantings were made at Me., Md., N. Y., Pa., and R. I. Uniform row plantings were also made in the spring at these locations except for R. I. Fall row plantings were made in N. Y. and R. I. Uniform clipping treatments are given these row plantings at all locations. More accurate and reliable data have been collected from the 1959 plantings.

In N. Y. comparisons were made between a planting of alfalfa made on May 1, 1959 and one made on August 5, 1959. The cutting date experiment was cut on September 16th, 23rd, and 30th and the plants were evaluated on October 21st. Varieties as well as cutting dates produced highly significant differences in plant height and also in plant type. For plant height the variety x cutting date interaction was highly significant for both plantings showing that the amount of difference between varieties varied according to when they were cut. For plant type the variety x cutting date interaction was highly significant for the summer planting, but not significant for the spring planting. Thus, any of the cutting dates used would have been satisfactory for bringing out differences in plant type for the spring planting, but not for the summer planting.

In the spaced plant experiment variety differences were highly significant for both plant height and plant type in both the spring and summer planting. The variety differences were greater for the spring planting than for the summer planting. Du Puits and Williamsburg tended to be tall and upright. Narragansett and Vernal tended to be shorter and prostrate.

Successful plantings were established in Me., R. I., Md., and Pa. Data from these plantings will be available for comparison with the N. Y. plantings.

During 1959 forage crop seedlings were grown under 48 different environmental conditions in light chambers. Pink, daylight, and white fluorescent tubes were used in combination with red, blue, green, and gold, the colors previously used. The white tubes gave high intensity light and thus produced rapid growth. With this light, 14-hour photoperiod and warm temperatures, it was possible to distinguish northern from southern alfalfas two weeks after planting. Northern varieties started to grow after this time so that the difference between the two types decreased rapidly. Thus, the difference between types was less under white lights than under red and green when the plants were six weeks old.

An experiment was set up using a 10-hour light period with the temperature at 80° F. The dark period consisted of 10 hours at 39° F., 2 hours dropping to this temperature and 2 hours rising back to 80° F. Red and green tubes were used in one chamber and white in the other. With this temperature treatment, the northern varieties made very little growth. Southern varieties under the white lights made rapid growth and under red and green lights made moderate growth. By the eighth week, the California Common plants grown with red and green lights were 4 times as tall as the Ranger plants. At the same time the California Common plants grown with white lights were 12 times as tall as those of Ranger. The intermediate varieties, Buffalo, Williamsburg, and Du Puits, were very similar to the northern varieties, Vernal,

Narragansett, and Ranger for the first six weeks. After that the intermediate varieties grew faster and by the end of the tenth week Du Puits was 2½ times as tall as the northern varieties, while Buffalo and Williamsburg were nearly twice as tall as the northern varieties. This amount of difference would be useful in separating northern from intermediate types, but the test needs to be accelerated.

An experiment was conducted to see if light and dark periods longer or shorter than 24 hours could be utilized to increase the difference between types of alfalfa or to speed up the test. Alfalfa seedlings were grown under red and green lights with cycles of 12, 24, 30, and 36 hours. Light periods were 3, 10, 16, and 22 hours, respectively. This made a 9-hour dark period for the 12-hour cycle and 14-hour dark periods for the other three cycles. Short day response in some plants has been shown to be due to long nights rather than to short days. If this were true in the case of stem elongation in alfalfa, it might be possible to use long days as well as long nights and still obtain a short day reaction. This should result in faster growth and thus make it possible to conduct tests in less time. With 3 hours of light and 9 hours of dark, a long day effect was obtained. That is, the Ranger plants were nearly as tall as the California Common. With 10 hours of light and 14 hours of dark, the typical short day effect was obtained. Ranger was only 30% as tall as California Common. When the light period was extended to 16 hours even though the dark period was maintained at 14 hours, the Ranger was 55% as tall as California Common. With the 22 hour light period, the Ranger plants were 70% as tall as the California Common plants. Thus for separating types of alfalfa, the 24-hour cycle was better than either longer or shorter cycles. Long nights were not entirely responsible for the short day reaction.

Some red clover plants grown under white fluorescent lamps plus incandescent bulbs or under pink and green fluorescent lamps plus incandescent bulbs blossomed one month after they were seeded. Bringing plants into bloom in a short time offers possibilities for varietal identification because the plants can be observed for date of bloom, number of internodes before blooming, as well as for the appearance of the flower. Alfalfa and birdsfoot trefoil have been made to bloom six weeks from the time of planting. It has been possible to get a few plants of Essex timothy to head in six weeks, but very few plants headed even by the tenth week.

Work with osmotic pressure consisted of using dry heat to change the germination of seed lots of birdsfoot trefoil. By heating the seed for different periods of time, five sub-lots with different germination percentages were obtained for a seed lot of each of three varieties. These are being germinated under osmotic pressure to see what relationship high and low germination will have on the test.

A rapid method of testing alfalfa plants for resistance to bacterial wilt has been developed by Dr. J. H. Graham of the U. S. Regional Pasture Research Laboratory, University Park, Pennsylvania. This method consists of inoculating leaf petioles with wilt bacteria. This method is being investigated to see how rapid a test can be made for trueness-to-type.

Plant hormones, gibberellin, dysiston, duraset, and an experimental chemical, BO-93, have all been shown to alter the growth of forage crop seedlings. With applications of gibberellin to birdsfoot trefoil varieties a large differential response was found. In some experiments, the stems of Empire were increased in length 800% by gibberellin as compared to 400% for Viking or European. The results obtained with these chemicals seem to be markedly influenced by environment.

USEFULNESS OF FINDINGS:

The field work is providing information that will be helpful in deciding when to cut alfalfa at the different locations to obtain the best expression of difference between varieties in the fall.

A test requiring only two weeks has been developed for detecting admixture of southern alfalfa in northern varieties. This will be of value as a rapid test for this type of contamination and should aid in preventing such seed from being sold to the farmer. The use of alternating temperatures also offers a possibility of separating intermediate plants from northern plants. This test might be of value in evaluating plant introductions or breeding lines.

Bringing alfalfa, birdsfoot trefoil, and red clover into bloom in a short time will be valuable in varietal identification and might also be useful for producing seed in a short time.

WORK PLANNED FOR NEXT YEAR:

The space-planted experiments and the cutting date experiments will be evaluated at each location and the data for the five states will be compared.

Additional plantings are planned at several locations to duplicate the date of cutting experiments to determine the effects on the year old plants as compared with seedling year plants.

Research will be continued with growing seedlings under different combinations of photoperiod, color of light, intensity of light, and temperature. Until the present time, work with different temperatures has been limited because the light chambers used had no temperature controls. Growth chambers will soon be available that will permit complete control of temperature. Light conditions that have appeared to offer promise will be used in the new chambers in combination with different temperature treatments. The effect of constant temperatures will be compared to the effect of alternating temperatures consisting of various combinations of warm and cold periods. Vegetative growth as well as blooming will be studied to find ways of distinguishing types and varieties. Conditions that promote early blooming will be sought. Chilling seeds and seedlings of various stages of development for various lengths of time will be tried to promote early flowering. The use of plant hormones to promote blooming will be tried in combination with the more promising light treatments. Many chemicals that affect the

growth of plants are available. Several more of these will be used. The best concentration, time of treatment, and number of applications will be worked out for each. Varieties will be observed for difference in response.

In the work with osmotic pressure, investigations will be continued to find causes of variation between seed lots within varieties. Seeds of several lots of birdsfoot trefoil have been subjected to dry heat to alter the germination of sub-samples of those lots. Thus, samples with the same genetic make-up but with different germination percentages have been obtained. These will be tested under osmotic pressure to learn what effect high or low germination have on the test. Seed lots germinating poorly under osmotic pressure will be subjected to cold tests and other tests to see if lack of ability to germinate under pressure is correlated with weakness of the seed.

The method of inoculating leaf petioles of alfalfa with bacteria as a means of testing plants for resistance to bacterial wilt will be tried. Seedlings of different ages will be inoculated by this method to determine how old the plants must be for a satisfactory test. Inoculated seedlings will be grown at different temperatures to determine the best temperature for conducting the test.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: D. C. Shelton, Chairman, Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations; F.C.R.B., D.C.R.B. and S.E.S.D., A.R.S., U.S.D.A.

RESULTS:

Objectives of the newly revised project are: (1) to evaluate various forages grown under known conditions and harvested at specific dates and stages of maturity by determining digestible protein and digestible energy, (2) to develop methods for the nutritive evaluation of forages: these to include the use of biological and chemical techniques and (3) to conduct supplementary animal-production and voluntary consumption trials insofar as possible.

Some revisions were made in the contributing projects, thus permitting further exploration and development of new ideas concerning ways to measure forage quality.

The cooperative regional study (Md., Mass., N. H., N. J., and Pa.) to compare the digestibilities of dry matter, protein and energy of 28 different forages using cattle and sheep has been completed and published. The digestibility data obtained with both species of animals were not significantly different ($P > .05$).

Among the factors under study as influencing the digestible dry matter, protein and energy of forages are the following: (1) cutting time and growth stage (Del., Me., Md., N. H., N. Y., Pa., Vt., and W. Va.), (2) nitrogen fertilization (Del., Me., N. H., N. Y., Pa., R. I. and W. Va.), (3) preservation - silage (N. J.), frozen and refrigerated forage (N. J.), fresh, freeze-dried and oven-dried forage (W. Va.), (4) weathering, crimping and crushing (N. Y.), (5) geographical location (N. Y. and Vt.) and (6) plant varieties (Del., Md., N. Y. and Vt.).

Maturity of the forage influences greatly its nutritive value. For instance, studies with orchardgrass, bromegrass and timothy indicate that after approximately May 15 (date within region may vary) each day of delay in making the first cutting resulted in approximately 0.5% absolute reduction in digestibility of energy. Concomitant decreases in protein digestibility were not as great. This is generally true for legumes, but other factors may influence this relationship. With bluegrass, the cellulose digestibility coefficient declined approximately 0.5% per day. The importance of cutting time in relation to maturity continues to occupy the attention of nearly all stations of the region.

In areas where regional climatic conditions are generally unfavorable to maintenance of alfalfa stands, studies on management practices to enhance the yield and digestibility of grasses continue to be pursued vigorously. By nitrogen fertilization the apparent digestible protein content of grasses is increased (Me., N. H., N. J., N. Y. and R. I.) although in general digestible energy has not been affected. Some variation in the digestible energy data has occurred among stations. Whether such variations can be accounted for by seasonal variation, species of grass, etc. awaits additional investigation.

Availability of nutrients as influenced by conditions of preservation is receiving attention. Comparisons of bromegrass and alfalfa as silages and as fresh material maintained under refrigeration (33-36° F.) are being made (N. J.). Bluegrass in the fresh state, freeze-dried and oven-dried (65° C.) has been evaluated by the *in vitro* fermentation procedure. The digestibility of the freeze-dried grass was consistently higher than the oven-dried. Results with fresh grass were quite variable - both between replicated samples and between trials. This may be due to the difficulty in preparing a representative and homogeneous small sample of fresh grass (W. Va.). The effect of the temperature of drying and the effect of freezing on apparent lignin content are being investigated (U. S. Reg. Pasture Res. Lab.).

Emphasis on biological and chemical methods for the nutritive evaluation of forages has increased. Highly encouraging are the results obtained by: (1) *in vitro* fermentations (W. Va.), (2) use of the rabbit as an assay animal (Del.) and (3) acid-insoluble lignin in prediction of quality (U. S. Reg. Pasture Res. Lab.). Highly significant correlations (+0.86 to +0.93) were obtained for the *in vivo* - *in vitro* digestibility relationships of bluegrass. Significant differences due to stage of growth, cutting

procedure and nitrogen fertilization were obtained for digestible dry matter, cellulose, protein and energy by the in vitro technique. Using 106 forage samples of known in vivo digestibility received from other stations of the region, there is a highly significant correlation (+0.88) between in vivo digestible dry matter and in vitro digestible cellulose (W. Va.). Regression equations for grasses and legumes have been prepared from the digestible dry matter for rabbits to predict the same for sheep (Del.).

The interaction of voluntary intake and digestibility of a forage as measured with animals appears to be closely related to forage quality. Studies on this relationship are in progress (Md., Pa., W. Va.).

Production response of dairy cows has shown that: (1) the highest yield of dry matter per acre, digestible energy per acre and milk per acre were obtained by harvesting the first cutting (May 27) at the full bud stage (Md.); (2) with an alfalfa-bromegrass mixture harvested (June 5) at the early-bud stage, the ad libitum digestible dry matter intake and the milk production were approximately 40% higher than when the forage was harvested (July 15) at early seed stage (Vt.) and (3) the addition of grain will frequently augment the digestibility of the total ration (Mass.). In some areas of the Northeast and with appropriate nitrogen fertilization, grass forages may compare very favorably with legume forages on the basis of acre yield (Me., Mass., N. H.).

USEFULNESS OF FINDINGS:

Since sheep-cattle digestibility data are mutually applicable, the cost of making animal digestibility evaluation of forages can be reduced by using sheep. The quantity of forage from research plots will frequently be adequate for digestion trials with sheep.

With appropriate nitrogen fertilization, grass forage can be produced to compare favorably with legume forage as to yield and quality (digestible energy and digestible protein). Furthermore, recommendations as to the most economical level of nitrogen fertilization consistent with yield of digestible nutrients should soon be forthcoming.

The data accumulating at nearly all stations of the region on the relation of cutting date and maturity to nutritive quality of forages have served as a basis for revision of recommended management practices for legume and grass hays.

Rapid progress is being made toward the development of simpler means to predict nutritive quality of forages.

WORK PLANNED FOR NEXT YEAR:

The work projected for the coming year will be a continuation of that in progress. Subject matter areas about which studies are to be concentrated include: (1) defining for the region the relationship of digestibility with date of cutting and maturity of the forage, (2) development of simpler laboratory techniques such as *in vitro* fermentation, chemical means and others to measure forage quality, (3) relation of voluntary consumption and digestibility (*in vivo* and *in vitro*) of the forage, (4) the use of milk production and other measures of production as criteria of forage quality and (5) the influence of nitrogen fertilization, conditions of preservation, weathering and plant variety on forage digestibility.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST.

Leader: W. R. Battle, Chairman, Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations; F.C.R.B. and S.E.S.D., A.R.S., U.S.D.A.; and A.S.T.A.

RESULTS:

Breeding and evaluation of alfalfa, Ladino clover, orchardgrass, bromegrass and timothy was carried out under this project during 1959. Responsibility for investigations with the various species was assigned as follows:

Alfalfa - Me., R. I., Conn., N. Y., Pa., N. J.
Ladino clover - N. H., Vt., N. Y. Md.
Orchardgrass - N. Y., Pa., Md.
Bromegrass - N. H., N. Y., Pa.
Timothy - Me., N. Y., Pa.

Breeding materials studied included the most promising selections that have resulted from cooperative research carried out with these species over a 10-year period. They are being evaluated in the form of clones, polycross progenies, and synthetic varieties.

Adequate evaluation of these perennials can only be accomplished over a period of years, and the past season's activities have contributed toward that end. Complete research information on yield, persistence, and adaptation of each species at each location has been summarized, analyzed statistically, and compiled into a regional report of some 100 pages of data. The data include seasonal performance as well as average performance over the entire testing period, and provide for comparison with certain standard check varieties.

USEFULNESS OF FINDINGS:

The additional season's data on each species at each of several locations has been a major contribution toward finally assessing breeding potential of the materials. Relative persistence, productivity, and adaptation of the selections is being clearly delineated, as is their potential usefulness in formulating new and superior synthetic varieties.

This and previous season's work provides information that points toward those materials that should be combined into synthetic varieties, and those that offer promise of yielding valuable results under a program of second-cycle selection.

WORK PLANNED FOR NEXT YEAR:

Evaluation of currently established materials will be continued through at least one more season. Newly synthesized varieties of alfalfa, bromegrass and orchardgrass will be incorporated into the program. Seed increases of additional new synthetic varieties of alfalfa will be accomplished for use in future regional evaluation.

Title: PROJECT NE-29 - MANAGEMENT AND PRODUCTIVITY OF PERENNIAL GRASSES.

Leader: A. M. Decker, Chairman, Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations; Forage and Range Res. Br. and S.E.S.D., A.R.S., U.S.D.A.

RESULTS:

The objectives of this revised experiment are: (1) to determine the influence of harvest management treatments at different stages of development of pure grass stands; (2) to determine the influence of these cutting treatments on the plant morphology, physiology, carbohydrate reserves, and relative nutritive value of several grasses; and (3) to relate the above objectives to the immediate aboveground microclimatic and soil environment. A fourth objective is to complete publications on forage management investigations already completed.

Uniform plantings were made at nine Experiment Stations. A single seed lot for each species was seeded at each location as follows:

State Experiment Station	Species and Varieties
Connecticut	Potomac orchard, S-37 orchard, reed canary and Lincoln brome
Maine	Lincoln brome and Climax timothy
Maryland	Saratoga brome, Potomac orchard, Pennlate orchard, and reed canary
New Jersey	Lincoln brome, Potomac orchard, reed canary, and Climax timothy
New York	Lincoln brome, Saratoga brome, Potomac orchard, Pennlate orchard, and reed canary
Pennsylvania	Potomac orchard, Pennlate orchard, reed canary, and Climax timothy
Rhode Island	Saratoga brome, Potomac orchard, and Climax timothy
Vermont	Saratoga brome, S-37, reed canary, and Climax Timothy
West Virginia	Potomac orchard, and Climax timothy

Root studies are to be made on each underlined variety. Each variety is thus being tested at a Northern and a Southern station in the region.

Fair to good stands were obtained at all stations by the fall of 1959 even though a second seeding was required at Me., Conn., W. Va., and Vt. Reed canarygrass stands were outstanding at N. Y., N. J., Pa., and Md. Pennlate orchardgrass stands were less vigorous than those of Potomac at Md., N. Y., and Pa. Even though considerable variation existed between species at the various locations, stands were acceptable in all cases.

Detailed uniform management procedures will be followed and statistical analyses employed in order that uniform data may be collected and processed at each Station. Field data forms will be printed and distributed to insure that data will be uniformly recorded at each Station. Data collection will begin during the spring of 1960.

Statistical analyses of data collected from 1954 through 1958 were completed for all but one of the NE-29 experiments conducted during this period.

Collection and summarization of climatic data by nine cooperating states have continued during the past year. These data are being summarized at the Regional Pasture Laboratory.

USEFULNESS OF FINDINGS:

The seed lot of reed canarygrass used for these plantings was of excellent quality, and good stands were obtained at all stations. Poor stands of this species are frequently obtained and are often associated with low quality seed.

Four years' results of experiments throughout the Northeast provide basic information on the factors which govern establishment, production and persistence of several important forage species within the region. These findings are being made available to research, teaching and extension personnel throughout the country. As a result, farmers and livestock producers throughout the country will benefit.

WORK PLANNED FOR NEXT YEAR:

Publication of results on experiments completed will proceed rapidly. The newly established grasses will be harvested at four different stages of growth and at two heights of cut. Two rates of nitrogen will be used throughout the study.

Title: PROJECT NE-43 - PROFITABILITY OF ALTERNATIVE FORAGE SYSTEMS FOR NORTHEAST DAIRY FARMS

Leader: J. W. Wysong, Chairman, Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, except N. H.; S.E.S.D. and F.E.R.D., A.R.S., U.S.D.A.

RESULTS:

Data were collected from farmers relating to silage storage methods, practices and costs, and hay drying methods, practices and costs. Detailed time and motion studies were conducted as well as chemical and physical analyses of hay samples.

Experimental work was conducted on the response of forages to different crop sequence combinations and management practices (herbicides, cutting and fertilizer treatments).

Farmer experience data were collected about the yield response of forage crops to different management practices. Some of the survey data collected have been analyzed. This analysis showed that farms with relatively high crop yields were more profitable than those with low yields, but yield improving practices varied widely among farms. The larger the percentage of hayland in new seeding, the higher the crop yields, but the differences in yields were small. Farms stocked the heaviest with cattle had the highest crop yields, largely a result of the additional plant food from manure. The most profitable intensity of stocking was two to three crop acres per milk cow. Combinations of hay, grass silage, and corn silage resulted in more milk per cow than hay alone, largely because larger amounts of feed per cow were provided. Farmers' experiences, like college experimental trials, showed that early-cut hay produced more milk than late-cut hay.

Returns from hay drying were based on experimental results which indicated additional dry matter and increased protein content of the artificially dried hay as compared with field cured hay. Investment costs and operating costs of different drying systems were obtained from cooperating farmers and the University of Delaware Hay Research Farm. Variable costs fluctuated according to the amount of moisture removed, fuel and electricity being the main components. Fixed costs per ton and per acre varied with changes in the quantity of hay dried. The profitability of hay drying was determined by comparing the returns per acre with the costs per acre. Returns were sufficient to cover total drying costs per acre only with the mow drying system under 1949-58 price levels. Variable costs were recovered under the mow-drying and platform drying system at all assumed levels of prices. However, not even variable costs were recovered with the wagon driers.

USEFULNESS OF FINDINGS:

Findings from these studies will assist farmers who seek information on the effect upon farm income of alternative forage patterns and practices under various farm situations. Since economic evaluations are essential to choosing profitable forage systems, results of these studies will provide an improved basis for decisions, thus assisting in preventing costly mistakes in management. Material assistance will be provided farmers in choosing from a wide range of cropping systems and harvesting methods the most profitable combination for their farms. The ultimate effect will be a more efficient and more profitable farm business.

Findings will be useful in building economic and agronomic phases of county extension programs in the region.

The work has stimulated research in related fields which should provide better methods of measuring forage stands and forage quality.

WORK PLANNED FOR NEXT YEAR:

Eight states will conduct work under the regional project throughout the coming year. Me., N. H., Pa., and Vt. will have no contributing projects.

A regional bulletin related to research results in the area of artificial hay drying will be prepared for publication.

Research will continue on the physical response of forage crops to different management practices. This experimental work will be analyzed to determine the economic implications of the results. The crop sequence and management practices (herbicide applications, cutting practices, fertilizer applications) research will be interpreted economically through budgetary analysis. Additional work will be done on the development of synthetic farm situations for budgeting purposes.

Additional survey data will be collected on existing farm operations to show the effects of forage patterns and practices on yields of forage and livestock products. These data, together with those already collected, will be analyzed to determine the economic impact of different patterns and practices on the farm business.

The economic effects of alternative methods of curing and storing forages will be evaluated through the use of data collected from farmer experiences and controlled experiments. Data will be collected on wagon hay driers and hay pelleting operations. Additional input-output data on feeding from horizontal and tower silos will be collected. These data developed from experimental evidence and farmers' experience will be used in a budgetary analysis of forage curing and storing alternatives.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization (Greenhouse): During the seedling stages alfalfa grown on strongly acid, very phosphorus deficient Paxton loam soil, 18" deep, had much larger tops and far greater root systems in each of the three 6" zones when all of the 300 pounds per acre of 46% superphosphate was banded 1.5" below the seed than where it was mixed with the upper 6" or throughout the entire 18" of soil. As in former experiments, however, the marked early advantages from banding superphosphate had mostly disappeared before reaching the early bloom stage.

Field W11: Seedings of 3 varieties of alfalfa in mid-summer of 1958 on rather poorly drained, but liberally fertilized Paxton loam soil, gave the following results during the wet season of 1959:

1) Narragansett was decidedly better than DuPuits and Vernal but all of the three varieties had very poor stands on the wettest sections of the field.

(The next statements are based on the results where there were fair to good stands of alfalfa in 1959.)

In the first harvest year, stands of all varieties of alfalfa were not affected appreciably by drilling the seed or by banding P or PK but, with DuPuits and Vernal, were improved by seeding with timothy.

First cutting yields were increased slightly by banded P and seeding timothy.

Second and third cutting yields were very similar for all treatments.

In general these results are further confirmation that the very beneficial effects of banded superphosphate on seedling growth of alfalfa do not continue to the harvest stage.

G14S: On previously untreated, acid soil (pH 5.2), liberally fertilized with superphosphate, muriate of potash and borax, dolomitic limestone at 2, 3, 4, 5 and 6 tons per acre, disked in just before August 1958 seedings of alfalfa, trefoil and Ladino clover, resulted in unsatisfactory stands of those legumes. At the lower liming rates replacing one ton of limestone with 3/4 ton of hydrated lime gave slightly better results. This experiment was repeated on another section (G14N) of the same area in 1959. The establishment was better than in 1959 but no marked differences in stands or growth were noted during the late summer and fall months.

Field P5: Alfalfa was seeded in late July, 1959, on a soil with pH about 6 and "medium" in available phosphorus. Disked in superphosphate (46%) was varied from 200 to 1600 pounds and dolomitic limestone from 1 to 16 tons per acre. Seedling growth was decidedly better on the high than on the low rates of superphosphate but no appreciable differences were noted between rates of limestone. These findings are in line with previous results, in that phosphorus is a very effective "starter" while high calcium and low acidity in soils increase the longevity of stands.

Field G15: Because of widespread winter killing on all plots, the fertilization - cutting management experiment was terminated in mid-summer of 1959. The results of the previous four years with a 1954 seeding of Rhizoma alfalfa and timothy are summarized below:

1) Potash (K_2O) at 270 pounds per acre, per year, resulted in no better stands or yields of alfalfa than 180 pounds.

2) The only appreciable benefit from fertilizer nitrogen at 180 pounds per year occurred in the first cutting of the first harvest season when the approximate increase was 18 pounds of dry matter per pound of nitrogen. Under cutting systems which maintained vigorous stands of alfalfa, the 4 year average yields were practically the same from the no-nitrogen as from the nitrogen plots.

3) Although Rhizoma withstands frequent cutting much better than Buffalo, five or more harvests nearly exterminated the alfalfa the first season.

4) Of the 4-cutting group those with shorter intervals between harvests early in the season and longer periods later, maintained better stands than those with growing periods of the same length from spring to fall.

5) Three cuttings at 42 day intervals, the last about September 1st, resulted in much poorer stands of less vigorous alfalfa than two 42 day plus one 84 day system, the last cut about October 10th. However the quality of that October harvest was very poor.

(b) Varieties: The winter of 1958-9 killed more alfalfa in Connecticut than any winter in 40 years. In seedings of 1956, Narragansett suffered the least reduction in stands, Vernal a close second, Atlantic third and DuPuits a low fourth among the named varieties. In the 1958 seedings none of those varieties suffered severe winter killing.

Ladino Clover Experiments: Previous work has shown that luxury consumption of potassium by Ladino occurred with large, infrequent applications of muriate of potash. Recent comparisons of potassium meta-phosphate, potassium calcium pyro-phosphate and muriate of potash in greenhouse and field experiments have shown that luxury consumption still occurred when large amounts of the meta- and pyro- phosphates were applied at one time. This was true even of the -6 + 16 mesh materials.

Trefoil: (a) In August 1958 the Viking, Mansfield and Empire varieties of trefoil were seeded alone and in several mixtures, using 8 pounds per acre of trefoil in all cases. In 1959 the best stands of all varieties in mixtures occurred with timothy (seeded at 4 lbs.) the poorest with alfalfa (seeded at 8 lbs.) or orchardgrass (seeded at 4 lbs.). With Ladino clover (seeded at 2 lbs.) the stands were intermediate.

(c) Grazing Management: At the end of the fourth season of differential grazing somewhat better stands existed where a June 15th cutting of hay was harvested, followed by grazing when 6" tall than where grazed when 6" to 10" tall.

Title: THE USE OF HERBICIDES IN FORAGE CROP MANAGEMENT

Leader: R. A. Peters

Spring seedlings of either alfalfa or red clover alone, produced nearly a ton of hay at each of two cuttings during the seeding year when the competition of weeds was eliminated by spraying with selective herbicides.

Again, worthwhile stands of Ladino clover were obtained without tillage by frost-crack seeding it on a permanent pasture where the vegetation had been killed the previous fall with herbicides.

DELAWARE

Title: ACCEPTABILITY OF HEAT CURED HAY MIXTURES BY THOROUGHBRED HORSES

Leaders: W. H. Mitchell and J. H. Shropshire.

Additional work on the acceptance of different types of hay by horses has been conducted. Six horses were given baled and pelleted hay on a "free choice" basis over a period of 43 days. Significant differences were noted between animals, some showing a strong preference for baled hay and some a strong preference for hay pellets. It seems significant that pellets constituted over 25% of the daily hay intake of all horses with the average being over 40%. Digestive disturbances have not been noted in any of these feeding trials.

Reverse type feeding trials were conducted with four horses first using pelleted hay for three weeks followed by a comparable period on baled hay. Three hay mixtures were used: alfalfa-orchardgrass, alfalfa-bromegrass, and alfalfa-Reed canarygrass. When horses were restricted to hay pellets only, some showed a significant decrease in daily consumption of hay. No significant changes in animal weights were noted although it is realized that the feeding periods were of short duration.

A very significant change was noted in the acceptance rating of different hay mixtures as the change was made from baled to pelleted hay. The orchardgrass mixture in all cases showed a decided increase in acceptance when in the form of pellets.

Title: IRRIGATION AND NITROGEN FERTILIZATION OF LADINO CLOVER, ALFALFA, BIRDSFOOT TREFOIL AND ORCHARDGRASS

Leader: W. H. Mitchell

This study involves the application of 0, 1", 2" and 4" of water where moisture is reduced to about 1/2 the available water holding capacity at depths of 6", 12" and 24". Nitrogen levels are 0 and 150 pounds per season applied as ammonium nitrate in 50 pound increments.

Data have been collected for 3 years -- 1957, a dry year; 1958, a wet year; 1959, a more normal year with a short summer period of low rainfall.

Following the second harvest in 1958 there was a high mortality of orchardgrass under the nitrogen treated plots. Since orchardgrass is included in 4 of the 7 species combinations studied this loss of stand prompted an August reseeding of all plots. Initial stands were excellent but severe winter killing seriously reduced the stands of birdsfoot trefoil and orchardgrass.

Again in 1960 a very significant loss of stand occurred in the nitrogen treated plots but in this case following the third harvest. This appears related to the height of cut in that the most serious mortality occurred where the cut was 2" or less. Where irregularities in the soil surface resulted in cuts higher than 2", the cutter bar height, injury was less severe.

This is the third year that root samples taken to a depth of 24" have shown less growth in terms of dry weight and surface measurements where nitrogen has been used.

During 1957 and 1959, years when irrigation water was used, root growth was decreased where water was applied. Although water was not used in 1958, a season of high rainfall, there was a significant difference in root development associated with irrigation treatments made the previous season.

Title: A COMPARISON OF ROW AND BROADCAST PLANTINGS OF GRASS-LEGUME MIXTURES

Leader: W. H. Mitchell

In these studies alfalfa-orchardgrass and red clover-timothy mixtures were seeded broadcast, components mixed in 8" rows, and the grass-legume components planted in alternate 8" rows. Nitrogen from urea was applied at 0, 100 and 200 pound levels to investigate possible plant space - fertilizer interactions.

The only advantage noted to date for the row plantings of grass-legume species is one of mixture control in the resulting hay. Continued observations are being made to determine possible relationships between persistence and plant spacing.

Title: NITROGEN AND PHOSPHORUS FERTILIZATION OF ALFALFA-GRASS MIXTURES

Leader: W. H. Mitchell

Additional attention has been given to the role of nitrogen and phosphorus fertilization in economical hay production. Evidence continues to accumulate favoring the use of a relatively large application of phosphorus at seeding time. Annual applications of potassium and boron appear adequate for maintaining high yields of alfalfa and red clover.

There appears to be little accumulation of soil phosphorus with annual applications of 50 lbs. P_2O_5. At the 100 and 200 pound rates there is a very noticeable increase. Plant phosphorus levels show a marked increase with each increment of phosphorus added to the soil.

Nitrogen applications have not given consistent yield responses but in general responses have been greatest when grass prevailed in the mixture and also during the establishment year. In the latter case the response did not prevail after the first cutting.

Increases in crude protein are generally associated with nitrogen applications. A notable exception was where urea was used as the nitrogen carrier on both alfalfa and red clover mixtures. It is theorized that the difference between urea and ammonium nitrate in this respect was related more to the maturity of the forage at harvest than to the nitrogen carriers per se.

MAINE

Title: NUTRITIVE VALUE OF GRASSES AS AFFECTED BY NITROGEN, DATE OF HARVEST AND REGROWTH INTERVAL

Leaders: B. R. Poulton, M. J. Anderson, T. N. Mellin, and R. C. Haven

Relatively pure stands of timothy were treated with 0, 50, 100, and 200 pounds of nitrogen per acre. Harvested forages were fed to dairy cattle and sheep for nutritive value studies. Results indicated that the use of nitrogen fertilization caused consistent increases in acre yields of digestible energy and digestible protein. Increases from nitrogen used above 100 pounds per acre were not nearly so great as those from nitrogen fertilization up to 100 pounds per acre.

Bromegrass hay fertilized with 72 pounds of nitrogen per acre was harvested and studied in digestion trials with sheep and production trials with dairy cattle. Digestion studies show this hay to have a T.D.N. content of over 60 per cent and a protein content approaching 10 per cent. Production

studies with dairy cattle revealed that this hay could support slightly higher levels of production than hays grown without nitrogen fertilization.

Several in vitro techniques for evaluation forage are being studied and compared with in vivo results. Results thus far indicate that acid-insoluble-lignin content of forage and artificial rumen data are highly correlated with in vivo nutritive values.

Title: CHEMICAL COMPOSITION OF MAINE ROUGHAGES

Leaders: Bernie E. Plummer, Jr., and A. Stanley Getchell

Work is being done determining the percentages of organic silage acids as an indication of quality of grass silage.

The chemical composition including lignin and cellulose of three varieties of timothy has been determined at three different cutting dates. Analyses have been made of the leaves and stems separately. Lignin was low in the early cut timothy with little difference between leaves and stems. Lignin content increased with maturity, increasing more in the stems than in the leaves. The average lignin content when cut June 10th was 4.20% for leaves and 4.72% for stems while that cut July 10th was 6.47% for leaves and 9.24% for stems. The ratio of per cent crude fiber and per cent cellulose between leaves and stems ran about the same and this ratio varies very little between samples cut June 10th and July 10th. This ratio is about 1 to 1.25, being higher in the stems. The per cent cellulose runs somewhat higher than the per cent crude fiber.

Title: HARVESTING PROBLEMS ASSOCIATED WITH HIGH-YIELDING FORAGE

Leaders: C. M. Milne and R. J. Rowe

A study was begun in 1958 with the primary objective of determining the effect of intensive fertilization of forage crops on the functional requirements of harvesting machinery. Large area plots (totalling 20 acres) of timothy, alfalfa, red clover and bromegrass were established. The grasses have been subjected to high-nitrogen fertilization of varying intensities, and the legumes have been adequately limed and fertilized.

Work thus far has been concerned with the effectiveness of various conditioning treatments on high yielding forages, as affected by level of fertilization and stage of maturity. Dry matter losses incurred in these harvesting systems have been determined. Results to date are strictly preliminary.

Title: FORAGE BREEDING AND VARIETY TESTING

Leader: C. R. Blackmon

Red Clover: Two new seedings of red clover varieties were established, one at Presque Isle and the other at Orono. Excellent stands of the following varieties were obtained: Pennscott, Dollard, Chesapeake, Ohio, Altaswede, Kenland, La Salle, and Lakeland. At Presque Isle, Lakeland red clover was the most resistant to northern anthracnose and mildew. This variety continued to be long-lived at that location with good stands maintained through the third year. In observational tests several Swedish red clover strains exhibited marked disease resistance and agronomic vigor.

Grass Nurseries: Twelve bromegrass and nine orchardgrass varieties were established in triplicated yield test plots at Orono during 1959. Preliminary observations indicated marked differences in growth. Several redtop, bluegrass, fescue, and ryegrass varieties or strains were seeded at Presque Isle in order to test their performance at this extreme northern point. Due to the increasing interest in grasses for turf and wildlife, additional variety tests are planned at Presque Isle in 1960.

Title: RATE OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON TIMOTHY

Leaders: C. S. Brown and P. N. Carpenter

The study begun in 1956 (1957 Annual Report, page 51) was terminated in the fall of 1959. No fertilizer was applied in 1959. Two harvests were made to measure residual effects of the previous three years of differential fertilization.

Uptake of nitrogen on the well-drained Bangor soil ranged from 33 pounds N for the 0 N treatment to 73 pounds N for the treatment receiving 300 pounds annual N in 1956-58. For the poorly drained Monarda soil the corresponding N uptake values were 42 and 97 pounds. Very little carryover of previously applied nitrogen was evidenced after the first cut.

Title: POTASSIUM SUPPLYING POWER OF MAINE SOILS

Leaders: C. S. Brown and P. N. Carpenter

A greenhouse study of grassland soils obtained from four locations each of seven major soils was conducted during the 1958-1959 greenhouse season. Potash release by these soils was determined, using Ladino clover as the test crop. A total of eight harvests were made.

Preliminary data indicate that soils relatively high in clay content released more native soil potassium than those of lighter texture. However, large differences between locations within a soil type were observed, apparently in response to past fertilization history.

Title: CLOVER COMPETITION STUDIES WITH ALFALFA

Leader: C. S. Brown

A study was made in 1959 of the effect of clover seeding rates upon the establishment of DuPuits and Vernal alfalfas sown at 8 pounds per acre. Hand separations were made to determine component yields. Yields of DuPuits were not affected by Ladino clover even at 4 lbs. per acre. Red clover had little effect except at the high rate of 12 lbs. per acre. Vernal was more sensitive to clover competition, with some depression by Ladino and red clover at 4 lbs., and appreciable depression by red clover at 8 and 12 lbs.

MARYLAND

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: R. C. Leffel

Evaluation of a 7000 plant nursery including 70 entries of red clover (1958 Annual Report, page 76) was completed in 1959. Results indicate that the previous ten year program of maternal line selection has resulted in a small increase in persistence. Most persistent selections from this nursery were propagated vegetatively during the winter of 1959-60 and are being investigated currently for degree of "pseudo-self-fertility". A study of first-generation inbred material and utilization of sterility alleles in single and double crosses of red clover is planned if sufficient self-seed can be obtained via "pseudo-self-fertility".

Title: LADINO CLOVER BREEDING, DISEASE, AND INSECT INVESTIGATIONS

Leader: R. C. Leffel

Clones, breeding materials, and seed lots of Trifolium repens were collected from the United States, Plant Introduction Section of the U.S.D.A., and foreign countries. A Plant Introduction nursery of 528 seed lots of white clover was established during the fall of 1959. Selected clones from various parts of the Northeast and Southeast are being studied currently for degree of "pseudo-self-fertility". A study designed to determine factors affecting persistence in Ladino clover was established in the fall of 1959, as was a management study designed to determine the effect of management upon persistence of Ladino clover.

Title: FORAGE CROP VARIETY EVALUATION IN MARYLAND

Leaders: R. C. Leffel, N. A. Clark and A. M. Decker

Alfalfa: Alfalfa variety tests, established during the fall of 1958 at College Park and Trappe, were evaluated for first-year forage yields during 1959. The variety test at College Park includes 6 alfalfa varieties seeded alone and 2 alfalfa varieties in all possible combinations with an early, medium, and late maturing variety of orchardgrass. All 12 entries are being subjected to 2 levels of soil fertilization and 2 cutting managements. The test at Trappe includes these same 12 entries plus 6 alfalfa synthetics from North Carolina. Fertility levels and cutting managements are not included in the Trappe test. Differences between fertility levels or cutting managements at College Park were non-significant. DuPuits appeared to be the most productive alfalfa among released varieties at both College Park and Trappe. Three of the six synthetics did not differ significantly from the yields of DuPuits at Trappe.

Red Clover: Red clover variety tests were conducted at College Park and Trappe in 1959. Chesapeake was superior to all released varieties at Trappe and was equal to all in yield at College Park. A test including 14 Maryland local red clover strains indicated that several such strains compared favorably with Chesapeake. Red clover variety tests established at Trappe and College Park suggested a marked superiority of Chesapeake in seedling establishment, possibly under drought conditions.

Ladino Clover: Some superiority of Pasture Laboratory Synthetic No. 1 was demonstrated, but all strains exhibited a lack of persistence in a variety test established in March, 1957. Certified California, Pilgrim, and Oregon, Iowa Synthetic, and Bohnert performed similarly in forage yield and persistence. Pasture Laboratory Synthetic No. 2 was inferior in both forage yield and persistence.

Lespedeza: Climax, Auburn Korean, and Rowan exceeded the forage yields of Korean, Iowa 6, and Kobe at College Park.

Forage Sorghums: A variety test of 18 forage sorghums was evaluated at College Park for maturity, height, and lodging. Variation in stands and effects of one plot upon another confounded lodging scores. It was apparent, however, that best lodging resistance existed among earliest or shortest sorghums; the most productive ones lodged severely. Atlas and Hegari were among the best sorghums in regard to lodging resistance and were satisfactory in other characteristics.

Sudangrasses, Pearl Millets, Johnsongrasses, Sorgrasses, Sorghum Almum, and Sorghum-Sudangrass Hybrids: In 1959 variety testing of these forages was conducted at the Forage Research Farm near Ellicott City. Plants were harvested to simulate pasture conditions. Extreme variation occurred in the maturity dates of the Sudangrasses. The Pearl millets fell in the maturity group with the later maturing Sudangrasses, and the Sorghum-Sudangrass hybrids ranked in the early maturing group. Seasonal total yields among the Sudangrasses were also quite variable. The Pearl millets and Sorghum-Sudangrass hybrids compared favorably in yielding ability with the more productive Sudangrasses. Leaf disease resistance among the Pearl millets and Sorghum-Sudangrass hybrids was higher than in the Sudangrasses.

Among the perennial species, the Sorghum almum yielded the greatest amount of dry matter with high leaf disease resistance. The maturity dates for Sorghum almum were comparable to those of the early maturing Sudangrasses. Plots of these perennial plants are to be maintained through the first harvest of 1960 at which time plant roots will be examined to determine the extent of rhizome formation.

Testing of the annual forage varieties will be continued in 1960 to further evaluate these plants.

Midland Bermudagrass: Variety tests at two locations in the Coastal Plain area of Maryland were continued in 1959 along with the establishment of a new location in the Piedmont area. Midland continues to be the highest producing variety at all locations being nearly twice as productive as common. Greenfield yields were nearly as good as Midland yields at some locations. However, both Greenfield and common were often severely damaged by leaf spot during the late summer. Coastal is not winter hardy at all locations, but is extremely resistant to the leaf spot diseases with Midland being intermediate for this characteristic. Suwannee has been completely lost from all locations.

Title: RESPONSE OF ORCHARDGRASS TO VARIOUS RATES OF POTASSIUM AND NITROGEN FERTILIZATION

Leader: C. B. Kresge

A 2 to 1 ratio of nitrogen to potash topdressed on orchardgrass proved to be the most satisfactory ratio for the second straight year. Maximum yield (3.78 tons of dry matter per acre) in 1959 was obtained with 200 pounds of N and 100 pounds of K_2O per acre (protein content of forage at this rate was 17%). There was no significant increase in yield at the 400 pounds of N : 200 pounds of K_2O per acre rate, at which the highest yield was obtained in 1958 (1958 Annual Report, page 78). Nitrogen and potash increased the per cent recovery of one another when applied in the ratio of 2 N to 1 K_2O. Per cent potassium recovery of all plots averaged 74% and 100% in 1958 and 1959, respectively. Per cent nitrogen recovery averaged 67% in 1958 and 41% in 1959. Maximum removal of P_2O_5 by the plant was directly related to maximum yield. Potassium deficiency symptoms of plants receiving no potash were severe. The K content of orchardgrass got as low as 1% when 400 pounds of N and 0 pounds of K_2O per acre were applied.

Title: THE EFFECTS OF NITROGEN RATES AND CLIPPING FREQUENCY ON THE PERFORMANCE OF MIDLAND BERMUDAGRASS

Leader: A. Morris Decker

A study was initiated in the spring of 1959 to determine total dry matter production, seasonal forage distribution, nitrogen recovery, and forage quality as influenced by nitrogen rates and clipping schedules. Plots were laid out in an area established in the spring of 1958. Nitrogen levels were 0, 100, 200, 400, 600, and 800 lbs. per acre applied as NH_4NO_3 in four equal applications. These plots were harvested 3, 4, 5, 6, and 8 times during the season. All plots were uniformly fertilized with 2,000 lbs. of an 0-10-20 fertilizer.

Dry matter yields for the first harvest year ranged from 1.46 tons/acre with no nitrogen and harvested 8 times to 7.97 tons with 600 lbs. of nitrogen and harvested 3 times. In general, 800 lbs. of N per acre produced no more forage than 600 lbs/acre. When considering both yield and forage quality, the most economical return per acre appeared to be between 200 and 400 lbs. of nitrogen per acre harvested either 4 or 5 times during the season.

Protein and fiber analyses are being obtained from this material.

Title: COMPARISON OF NITROGEN SOURCES ON ESTABLISHED BLUEGRASS SOD

Leader: C. B. Kresge

In contrast to the data obtained in 1958 (1958 Annual Report, page 79), there was generally no yield response of bluegrass to source of nitrogen in 1959. One exception was at the single application of 160 pounds of N per acre. At this rate yield increases due to NH_4NO_3 were greater than those due to urea. No significant increase in yield was obtained when 160 pounds of N per acre was split into 2 - 80 pound applications in early spring and after the first cutting. No difference in nitrogen recovery was noted except at the 80 pound rate of N where nitrogen recovery from urea (62%) and $(NH_4)_2SO_4$ (80%) exceeded that from ureaformaldehyde (44%) and NH_4NO_3 (48%). Per cent protein in the forage in 1958 was highest (17 to 22%) when urea was the nitrogen source. In 1959, NH_4NO_3 resulted in the highest per cent protein (18 - 24%). The residual effects of the four nitrogen sources will be evaluated in 1960.

Title: TIME AND RATE OF POTASSIUM APPLICATION TO ALFALFA AND ALFALFA-ORCHARDGRASS

Leader: C. B. Kresge

An overall evaluation of alfalfa and alfalfa-orchardgrass yields in 1959 revealed that there was no response to time or rate of potassium fertilization on a Wickham silt loam. However, the fourth replication of the experiment demonstrated a strong response to rate of potassium fertilization after the third cutting. Alfalfa in this replication showed potassium deficiency symptoms and a decrease in yield and stand at the lower rates of application (0 and 50 pounds of K_2O per acre). Deficiency symptoms and loss of stand occurred when the K content of the alfalfa was near 1.6% and 1.2%, respectively. It is apparent from this year's data as well as that of 1958 (1958 Annual Report, page 78) that this soil possessed a high "K-supplying power" and that two years of crop removal have been required to "drain" the soil of enough potassium to cause a deficiency in alfalfa. Fortunately, this experiment will continue, the value of long term experiments being exemplified by the results thus far obtained.

Title: ALFALFA FERTILIZATION

Leader: John Axley

The application of 800 lbs. of 0-10-30 to alfalfa continued to be best fertilizer when compared with similar quantities of 0-5-15, 0-10-10, and 0-5-10. A Beltsville silt loam is the soil on which the alfalfa is grown. It is a coastal plain soil and like many other coastal plain soils of moderate fertility, it exhibits little or no fixing capacity for phosphorus or potassium. This tendency is verified by alfalfa yields as influenced by time of fertilization as fall fertilizer treatments of 0-10-10, and are equally as effective in alfalfa production as spring treatments. In fact, treating the soil with 3 times as much 0-10-10 once in 3 years resulted in only a slight non significant reduction in yield of a 0.1 ton per year. These results are in direct contrast to research findings on soils with large potash and phosphorus fixing capacities. With such fixing soils, frequent application of fertilizer, even after each cutting, has sometimes been indicated. It is suggested that the fixing tendencies of soils be considered before recommendations for fertilizer rates and times of application be made.

Title: EFFECTS OF IRRIGATION AND FERTILIZATION OF FIVE FORAGE SPECIES

Leader: A. Morris Decker

Forage yields were obtained for the second harvest year (1957 Annual Report, page 55; 1958 Annual Report, page 80). Short periods of drought existed during the growing season with the result that 8.59 inches of irrigation water were applied to the low soil moisture tension plots. This amount of water resulted in approximately a half ton increase in forage production for all species. The addition of 3.65 inches of water to the medium moisture level plots resulted in approximately the same dry matter increases. Alfalfa yields were increased slightly when 0-15-30 fertilizer rates were increased from 500 to 1000 lbs. per acre. There was no additional increase at 1500 lbs/acre. Ladino clover stands were lost from all treatments. The addition of extra water increased the efficiency of nitrogen utilization by all three grasses. Nitrogen tended to be most efficiently utilized by Midland at the 400 lb. rate, by tall fescue at the 200 lb. rate and Kentucky bluegrass at the 100 lb. rate. Kentucky bluegrass stands were severely reduced during the hot summer months at the 400 lb. nitrogen rate.

Title: SOD-SEEDING ESTABLISHMENT TRIALS

Leaders: A. Morris Decker and F. Graham Swain

Sod-seeding experiments were continued for the second year (1958 Annual Report, page 81). This research has two principal objectives:

(1) To increase the fall and spring production of forage species sod-seeded into Bermudagrass.
(2) To develop a more suitable type of opener for sod-seeding small seeded legumes into Kentucky bluegrass.

Results in 1958-59 indicated that:

(A) Cutting the cereal rye in late fall did not significantly reduce the total yield of rye, when compared with yield from plots cut only in the spring.
(B) Higher seeding rates (90 lbs. per acre) and close row spacings (10 inches) did increase late fall production of the rye.
(C) Cereal rye outyielded all other grasses in the trial by approximately 1 ton D. M. per acre and produced the bulk of its yield much earlier in the spring.
(D) Vetch outyielded all species (3.37 tons per acre) and made the bulk of its growth in late spring.

During 1959-60 two main experiments were established. One experiment was designed to study the effects of very high seeding rates (180 lbs. per acre) high nitrogen rates (90 lbs. N per acre in fall and spring) and close row spacings (8 inches) on the late fall and total production of cereal rye. The other was set up to study the effects of time of planting of cereal rye and vetch sown alone and in combination.

Slow progress was made with sod-seeding Kentucky bluegrass as many problems were encountered. However, several promising experimental openers have been developed and are ready for trial during 1960.

Title: MANAGEMENT STUDY OF SUMMER ANNUALS

Leader: N. A. Clark

The summer annual management study will be continued in 1960. Sudangrass, Pearl millet, and a Sudangrass-Sorghum hybrid will be compared under 3 rates of nitrogen and 4 clipping treatments. Plants will be cut at 18 and 30 inch heights to stubble heights of 2 and 8 inches. Results in 1959 show good plant recovery from clipping to a 2 inch stubble.

Title: CONTROL OF VARIOUS WINTER ANNUAL WEEDS IN ALFALFA AND ALFALFA-GRASS MIXTURES - 1959-60

Leaders: P. W. Santelmann and J. A. Meade

The Effect of CIPC on Seedling Grasses - Several forage grasses were seeded together with alfalfa in Sept. 1959 and treated in Dec. 1959 with rates of 1 and 2 lbs. per acre of CIPC. Of the species tested, it appears that orchardgrass may possibly survive this treatment. Tall fescue, bromegrass and timothy were drastically affected by treatment.

Control of German Knotgrass in Alfalfa - Fall seeded alfalfa was treated at various times during the winter and spring in an effort to control this weed. It appears that under certain conditions high rates of Dinitro may control this weed but results are still uncertain. CIPC has also been applied to determine its effect on the weed. Rates of 2.5 and 5 lbs. per acre applied so far this winter made the foliage of the weed considerably darker. Control estimations must await spring growth.

The Effect on Alfalfa Yield When Dinitro and CIPC are Used to Control Chickweed - The results of this test indicate that CIPC is best applied as early as possible (Oct.). Treatments at a rate of 2 lbs. per acre as early as Oct. 10 and as late as April 17 had no effect on the alfalfa yield. Dinitro at 1.5 lbs. per acre applied in Oct. may have reduced the yield somewhat. November appears to be the best time for Dinitro treatments.

Pre-Emergence Control of Weeds in Alfalfa - Several herbicides at various rates were applied one day after seeding alfalfa in September. The results are not available yet but experiments of this type will be continued.

The use of 2,4-DB to Control Winter Annuals in Alfalfa - Alfalfa seeded in Sept. 1959 was treated with 2,4-DB at various rates during the winter and spring in an attempt to find any injury patterns which might be present. Yield determinations will be made this summer.

Title: INFLUENCE OF SOIL TEMPERATURE ON FORAGE GROWTH

Leaders: A. Morris Decker, N. H. MacLeod

Soil temperature control tests have been initiated with installation of a 6' by 15' tubing grid, placed at a 3" depth in the soil, through which a solution at a controlled temperature is pumped. Fifteen thermocouples have been placed at each of the 1, 3, 6, 9, and 12 depths to measure soil temperature. Soil moisture will be measured at these levels with Bouyoucos blocks.

Two thermoregulator systems are used: one to control the temperature in a solution supply tank to a control point just below that desired in the soil, the second to raise the temperature of the solution to that desired. The second regulator is placed in the tubing grid supply line.

After the effects of the equipment on soil temperature have been characterized, forage species will be grown from seedlings and vegetative material to study the influence of soil temperature on forage growth under field conditions. Bermudagrass, Kentucky bluegrass, orchardgrass, Ladino clover and alfalfa will be the test species.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leaders: A. Morris Decker and R. Z. Spry

Evaluation of four pasture combinations for beef production was continued for the fourth year (1958 Annual Report, page 80). Beef production per acre ranged from 406 lbs. with Kentucky bluegrass to 546 lbs. for the Midland-rye combination. The production from orchardgrass and reed canarygrass was intermediate. In addition to a 50 day longer grazing season with the Midland-rye combination, carrying capacity during this time was 0.3 of an animal unit higher than for the other three pastures. However, animal gains per day were slightly lower. There was a fairly close relationship between beef production and dry matter yields for all pastures with utilization being lower for Midland. Average production for the Midland-rye combination over the four year period has been 262 lbs. more beef per acre than orchard-Ladino, the next most productive pasture.

Title: THE EVALUATION OF PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark, A. M. Decker, Jr. - Agronomy Department
R. W. Hemken, R. F. Davis, and J. I. Leslie - Dairy Department

Grazing was initiated on June 1, 1959 on pastures of pure orchardgrass with three rates of nitrogen fertilization and orchardgrass in association with Ladino clover. While the first year results showed a sharper decline in seasonal dry matter yields in the grass-legume pasture than in the pure grass pastures this was not reflected in the milk production. Midland Bermudagrass with sod-seeded cereal rye will be included in the grazing study in 1960.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS

Leader: Allen L. Steinhauer

Alfalfa - There are four major insect pests of alfalfa in Maryland--the alfalfa weevil, the pea aphid, the meadow spittlebug and the potato leafhopper. Control of these pests is possible with available materials, but many of the more effective chemicals are unusable because of residue hazards. Research in 1959 was concerned mainly with finding outstanding control agents. A number of promising insecticides were found, but considerable work is necessary before any can be considered superior to existing practices. Insecticides which have shown promise include Guthion, Methyl trithion and dimethoate. This work will be continued in 1960.

Alfalfa research currently being inaugurated includes alfalfa weevil parasite introductions, variety tests for alfalfa weevil resistance or tolerance, and ecological and cultural methods of suppressing alfalfa weevil populations.

Clover - Studies on the biology of the clover root curculio are under way and participation in a project including the agronomy, plant pathology and entomology departments might help to clarify the contributing influences of this and other soil insects to the decline of Ladino clover.

MASSACHUSETTS

Title: THE NITROGEN FERTILIZATION OF ORCHARDGRASS

Leaders: W. G. Colby and Mack Drake

This project reported on previously as a nitrogen, potassium fertilization experiment with alfalfa-orchardgrass and Ladino-orchardgrass mixtures became a nitrogen fertilization experiment with orchardgrass when all of the legumes winterkilled during the winter of 1958-59. The following observations were made during the 1959 growing season; at Amherst, Massachusetts.

1. Nitrogen Response of Orchardgrass after Loss of Alfalfa from Winterkilling

Treatment	DM Yield of First Cutting
No N	2000 lbs. per A
100 lbs. N	3500 lbs. per A
150 lbs. N	3800 lbs. per A

2. Nitrogen Response of Straight Orchardgrass

Treatment	DM Yield of First Cutting
No N	600 lbs. per A
100 lbs. N	2400 lbs. per A
150 lbs. N	3000 lbs. per A

Note how the residual nitrogen from the winterkilled alfalfa helped maintain yields of the orchardgrass; also how a 50 to 60% grass stand in 1958 filled in for the winterkilled alfalfa in terms of yield in 1959.

3. Effect of Date of Cutting and Nitrogen Treatments on Yields of Orchardgrass

Dates of Cutting	DM Yields in lbs. per A	
	1st cutting	2nd cutting
(a) 100 lbs. of N applied in early spring		
May 28 (Heading begun) to July 2	1250	1050
June 4 (Heading complete) to July 7	2000	800
June 11 (Early Bloom) to July 17	2400	650
(b) 150 lbs. of N applied in early spring		
	1600	1500
	2750	800
	3000	650
(c) 100 lbs. of N in early spring; 50 lbs. after 1st cut		2100
		1750
		2000
(d) 150 lbs. of N in early spring; 50 lbs. after 1st cut		2200
		1500
		1800

We had hoped that a heavy application of nitrogen applied in early spring, combined with an early first cutting, might eliminate making a nitrogen application after the first cutting. Results were disappointing. Second cutting yields fell off badly except at the heaviest rate of nitrogen application on the earliest cutting. It appears that nitrogen applications must be made for each cutting for maximum yields.

Title: WINTER HARDINESS OBSERVATIONS ON ALFALFA AND ORCHARDGRASS STRAINS

Leaders: W. G. Colby and Martin E. Weeks

The winter of 1958-59 was unusually severe in terms of extensive winterkilling to both legumes and grasses. Although opinions differ, it is generally conceded that an extensive ice sheet which formed in January and persisted through February was at least one of the basic causes for so much injury. Observations on strain trials with alfalfa and orchardgrass revealed important strain differences in winter hardiness.

Survival Rating of Alfalfa Strains in Test Plots at Amherst
Massachusetts Agricultural Experiment Station
May 15, 1959

Strain	Test Plots								Total Rating
Narragansett	2	1	3	3	1	1	5	3	1
Vernal	3	2	3	3	3	3	3	3	2
N.Y. Synthetic A	5	2	3	3	2	1	5	3	3
Rambler	4	4	4	3	3	3	4	2	4
N.Y. Synthetic B	5	2	3	4	4	4	4	2	5
Ranger	3	2	5	3	4	3	4	5	6
Ind. Synthetic F	3	4	4	4	3	5	4	5	7
Atlantic	3	4	5	4	5	3	4	5	8
DuPuits	0	5	5	4	5	4	5	5	9

Ratings estimated from 1 to 5 in increasing damage due to winter weather. Rating of 0 indicates complete kill.

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Survival Rating of Orchardgrass Strains in Test Plots at Amherst
Massachusetts Agricultural Experiment Station
May 18, 1959

Strain	Heavy Nitrogen				Lower Nitrogen				Total Rating
Mass. (Colby's)	2	3	3	3	3	3	2	3	1
N.Y. Synthetic D	5	4	4	5	2	4	4	3	2
Penn Synthetic #3	4	4	5	5	3	5	4	2	3
Aurora	5	4	4	5	4	5	4	4	4
Potomac	5	5	5	0	4	4	4	4	
Penn Synthetic #2	0	0	0	0	5	5	5	5	
Hercules	0	0	5	5	4	4	4	0	
S-37	0	0	0	0	0	0	0	0	
Penn Synthetic #1	5	0	5	0	2	5	5	0	
Common	5	4	0	5	3	4	5	4	
Latar	0	5	0	0	4	0	4	0	

Ratings estimated from 1 to 5 in increasing damage due to winter weather. Rating of 0 indicates complete kill.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN MASSACHUSETTS IN 1959

Leaders: F. R. Shaw and W. J. Fischang

The investigations conducted during 1959 included population studies of forage crop insects, the biology of Sitona spp and evaluation of certain pesticides to control insects attacking alfalfa.

The population studies concerned the distribution and abundance of forage crop insects throughout the state together with weekly examination of forage of different compositions in the vicinity of Amherst.

A total of 84,000 insects was collected* and identified during 1959. Fields from all the major counties were examined excluding the off-shore islands. The following table (I) lists the abundance of the insects in a descending series.

Table I. Census of Forage Crop Insects in Massachusetts 1959

Insect name or group	% of group	% of total
Aphids (Mainly Macrosiphum pisi)		42.9
Plant bugs		23.3
Lygus lineolaris	47.2	
Adelphocoris lineolatus	23.8	
Halticus (Probably bracteatus)	7.7	
Trigonotylus ruficornis	5.8	
Leptoterna dolabratus	3.6	
Adelphocoris rapidus	3.1	
Capsus spp.	2.7	
Megaloceroea recticornis	2.3	
Plagiognathus politus	1.7	
miscellaneous Miridae	1.6	

* Collections consisted of 100-sweep samples made with a 15 inch sweeping net.

Table I (Cont'd.)

Insect name or group	% of group	% of total
Leafhoppers		17.9
Empoasca fabae	28.5	
Endria inimica	21.9	
Macrosteles fascifrons	20.9	
Aceratogallia sanguinolenta	10.4	
miscellaneous leafhoppers	4.0	
Athysanus argentatus	3.4	
Draculacephala spp.	2.8	
Paraphlepsius irroratus	2.2	
Aphrodes costata	1.1	
Doratura stylata	1.1	
Graminella nigrifrons	.9	
Scaphytopius acutus	.9	
Scaphytopius frontalis	.7	
Helochara communis	.6	
Graphalocephala spp.	.1	
Predators		4.5
Nabis ferus	68.2	
Coccinellidae	17.1	
Chrysopidae	10.1	
Syrphidae (Mostly Syrphus)	4.5	
Beetles		2.9
Tychius stephensi	35.9	
Flea beetles	24.0	
Hypera postica	14.6	
Popillia japonica	7.2	
Elateridae	6.3	
Calomycterus setarius	3.0	
Sitona hispidula	2.3	
Hypera nigrirostris	1.8	
Hypera punctata	1.6	
Sitona scissifrons	1.1	
Rhinocus castor	.8	
Sitona flavescens	.7	
Other insects		
Spittle bug (Philaenus leucophthalmus)		2.6
Miscellaneous		1.9
Grasshoppers (Mostly Melanoplus femur-rubrum and bivittatus)		1.2
Lepidoptera (Mostly loopers and alfalfa caterpillar)		.7
Sawflies		.5
Thrips		.4
Fulgoridae		.2
Membracidae		.1

Although the aphids are indicated as being most prevalent, this does not imply that they are most damaging. Populations of aphids can build up rapidly and decrease in a correspondingly short period. Only occasional fields in early spring or late fall have populations sufficiently high to warrant any consideration of control measures.

The abundance and distribution of the alfalfa weevil was less in 1959 than in the previous year. It may be speculated that the severe winter of 1958-59 which caused extensive loss of alfalfa also reduced the abundance of the weevil.

The leafhopper complex increased significantly in abundance compared with 1958 infestations. Empoasca fabae, Endria inimica, Macrosteles fascifrons and Aceratogallia sanguinolenta were the most abundant, comprising about 80 per cent of all leafhoppers.

In view of the current interest, particularly throughout the north central states, in the migratory habits of the potato leafhopper Empoasca fabae Harris, the following table is included:

Table II. First Appearances of Empoasca fabae in the Amherst Area - 1959

	Field Locations						
Date	Route 9	E. Hadley	Bay Rd.	Comins	S. Maple	Mill Valley	Total
May 25	0	0	0	0	2	2	4
June 1	0	0	0	1	0	1	2
8	0	0	0	0	0	0	0
16	0	cut	3	cut	1	4	8
22	0	0	cut	10	0	2	12
29	15	12	5	23	cut	6	61
July 6	cut	31	59	78	cut	56	224

Weekly collections which began in April revealed no potato leafhoppers before 25 May. Apparently the first wave of leafhoppers entered the Amherst area on westerly winds during the week preceding 25 May, with a second major wave during the latter part of June.

Sitona spp. were relatively low in abundance during 1959. The data that were obtained will be included in a forthcoming thesis by R. J. Lavigne.

No conclusions could be reached regarding variations in insect populations associated with composition of stands in 1959. The poor quality of stands, due to winter injury, probably causes the data to appear somewhat erratic.

Evaluation of Pesticides to Control Forage Crop Insects:

During the summer of 1959, a number of pesticides were evaluated using 1/100 acre plots. The procedure followed was to set up 20' x 20' plots in alfalfa fields and to make applications using compressed air sprayers. The amount of water used was 1 gallon per 20' x 20' plot or roughly 100 gallons of spray per acre. The following insecticides and dosages were evaluated:

Pesticide	Dosage actual pounds per acre
Dimethoate	1.0
Dylox	1.5
Experimental Nematocide (American Cyanamid)	1.0
Guthion	1.0
methoxychlor	2.0
Thiodan	0.5
Trithion	1.0
Sevin	2.0
Bacillus thuringiensis	2.0

All materials were emulsifiable concentrates except Dylox, Sevin and Bacillus thuringiensis. The temperature on the day of application was 80° F. The relative humidity was 47 per cent and the average height of the plants was 18.5 inches.

Following the pesticide applications, insect populations were determined in each plot by 50 sweep samples using a 15" insect net. The collections were made at 24 hours, 7 and 10 days after application.

Results:

1. Control of leafhoppers. Although several species of leafhoppers were present, only two species, Empoasca fabae and Macrosteles fascifrons, were sufficiently abundant to permit us to draw conclusions as to the effectiveness of the pesticides.

Dimethoate, Experimental Nematocide and methoxychlor were superior to the other pesticides for protection against Empoasca fabae up to 10 days after treatment.

Dimethoate, Trithion and Sevin gave the greatest reduction of Macrosteles fascifrons within 24 hours. After seven days, methoxychlor was superior to the other materials with Guthion, Sevin, Dimethoate and Trithion being slightly less effective. After 10 days the plots having Dimethoate, Sevin and Experimental Nematocide had the fewest numbers of this species. Bacillus thuringiensis did not appear to have much promise in the control of leafhoppers.

2. Control of plant bugs. Three species of plant bugs, Lygus lineolaris, Adelphocoris rapidus and A. lineolatus were present but only the first species was sufficiently abundant to permit conclusions to be drawn. Dylox and Dimethoate yielded the best control at the end of 24 hours. Guthion, Experimental Nematocide, Trithion and methoxychlor were somewhat less effective. At the end of seven days, Dimethoate and Guthion treated plots contained the fewest numbers of this species. After 10 days, Dimethoate continued to give superior control. The behavior of Bacillus thuringiensis against plant bugs is somewhat difficult to explain. After seven days, little reduction in abundance had resulted but after 10 days there was a low infestation. No explanation is available.

3. Aphids. The pea aphid, Macrosiphum pisi, was the only aphid present in sufficient abundance to warrant any conclusions being drawn. Dimethoate, Guthion, Sevin and Trithion, all reduced infestations completely within 24 hours. After seven days, the plots treated with Guthion and Trithion had the fewest number of aphids. Ten days after application, the infestation was lowest in plots treated with Dimethoate, Thiodan and Trithion.

4. Other insects. Too few weevils, grasshoppers and other forage pests were present to permit any conclusions to be drawn concerning the effectiveness of the pesticides under trial.

NEW HAMPSHIRE

Title: IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick (in cooperation with Forage and Range Research Branch, ARS, USDA)

The winter of 1958-59 was exceptionally severe, especially in southern New Hampshire, and stand losses of legumes were very heavy.

Yields were obtained for the third harvest season for 7 Ladino clover strains at Colebrook (1957 Annual Report, page 61). Relatively small yield differences were found, except for Wisconsin white clover, a small type, which flowered profusely and persisted very poorly. Pilgrim Ladino retained the highest average percentage of clover (54%) in a mixture with bromegrass.

Dieldrin gave almost complete control of Sitona spp. in 1959, but root rot was as severe as in control plots. Larvae populations of Sitona were extremely low until August, but gradually increased in control plots to about 150 per 8 linear feet by October, 1959. Methyl bromide was ineffective in control of soil fungi. Growth chamber studies also indicated that root injury by Sitona spp. does not appear to be a major predisposing factor for root rot. In the field, an unknown interaction occurred between dieldrin and

methyl bromide, since there seemed to be a significant reduction in root rot in the combination treatment. Yield data were erratic because of severe stand losses. Fusarium oxysporum constituted about 40-50% of the total isolates from rotted roots.

Fifty sections were plated from young lesions inside the taproot just beneath the crown. Three of these yielded F. oxysporum, 9 yielded Mucors, and 4 yielded Penicilliums. The latter 2 fungi are generally considered to be saprophytic. No fungi were obtained from the other 34 sections.

Field observations on plants selected for resistance to Curvularia trifolii in the greenhouse suggested that mature plant reaction differs from seedling reaction. Studies are in progress on the inheritance of resistance to this disease.

The pathogenicity of 45 isolates of 14 different fungi was determined on red and white clover seedlings by the test tube method. Pathogenicity varied widely among genera and within species. The same isolate produced similar ratings on both hosts. Isolates of Colletotrichum trifolii, F. oxysporum, Leptodiscus terrestris and Rhizoctonia solani were most pathogenic. Fungi pathogenic to insects were usually non-pathogenic on clover seedlings.

Ladino clones and seedlings were grown in a growth chamber at 400, 800 and 1500 f.c. Plant growth was best at 800 and 1500 f.c. and the higher light intensities favored more rapid development of flowers. Seedlings produced flower buds in 54 days under 1500 f.c. Temperatures used were 66° F. (night) to 74° F. (day), at a day length of 16 hours.

Artificial freezing tests were continued on hardiness of clovers. Factors which may affect results include: soil moisture, age of plants, temperature and duration of hardening period, rate of temperature decrease during freezing and increase during thawing.

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: G. M. Dunn and L. J. Higgins

Yields were obtained for the second harvest year for several bromegrass synthetics. Two or three of these seem to have good brownspot resistance, but yields were somewhat lower than the best check variety (Saratoga). Numerous polycross progenies were significantly better than check varieties for yield and resistance to Pyrenophora bromi.

All possible single crosses among 6 selected bromegrass clones were isolated for seed production in 1960.

A number of genetic mutants were found among S_1 and S_2 lines of bromegrass, including several chlorophyll-deficient types. Crosses were attempted in the greenhouse during 1959-60 by hand emasculation, followed by shaking the male plants over the emasculated panicles, or by bagging the 2 plants. The percentage of crossed seed by either method was very low. Methods of crossing are being investigated. Preliminary data on S_1 and open-pollinated progenies of yellow bromegrass plants indicate that inheritance is probably complex.

DuPuits and Narragansett produced significantly higher yields than Vernal and Ranger alfalfa in a 3 year test at Colebrook, New Hampshire.

New Hampshire red clover seed was obtained from crossing potted plants by bees in the greenhouse.

Replicated red clover variety trials were seeded August 6, 1959, since the excessive winter killing of 1958-59 destroyed any chance of persistence showing up from the 1956 seeding. Ten leading varieties, including New Hampshire, replicated four times were included in the 1959 planting.

Title: EVALUATION OF FORAGE SPECIES

Leaders: R. F. Lucey and N. F. Colovos

Saratoga bromegrass, S-37 orchardgrass, reed canarygrass and Climax timothy were established in the fall of 1959 at Nashua and Groveton, New Hampshire. At Nashua, in the absence of snow-cover, winter damage to S-37 orchardgrass was severe.

Herbage obtained on May 15, June 1, June 15 and July 1, 1959 for each species at each location was analyzed for acid insoluble lignin, gross energy and protein.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND SOILS AS RELATED TO IRRIGATION

Leaders: A. B. Prince and P. T. Blood

Bromegrass (Saratoga) and a mixture of bromegrass and Ladino clover (Pilgrim) were seeded in 1958. Topdressings of nitrogen and potassium in varying amounts were made in 1959. The effects of these treatments on yields were to be determined under irrigation versus non-irrigated conditions. Irrigation was to begin when the available soil moisture was 50% depleted. Unfortunately irrigation was not required. There was no response to potassium. Nitrogen applied at the 100 lb. rate caused severe lodging. In the bromegrass and Ladino clover plots most of the clover was winter-killed.

Three lysimeter experiments were conducted in a growth chamber. The effects of water treatment and soil temperature on the yields of test crops, amount of water moving through the soil (Merrimac sandy loam) and amount of cations leached were studied. The data indicated the following:

(a) When alfalfa was grown as a test crop, the highest yields were obtained with a soil temperature of 30° C. However, when oats were grown, the highest yields were obtained with a soil temperature of 25° C., next highest at 18° C., and lowest at 30° C.

(b) When alfalfa was grown as a test crop, the greatest amount of leaching took place at 18° C. and the least at 30° C. When oats were grown as a test crop, the greatest amount of leaching took place at 18° and 30° C. and the least at 25° C. These amounts were related to the growth of the test crop.

(c) The losses of cations in all three experiments were roughly proportional to the amount of leachate obtained.

(d) Losses of calcium were highest, followed by magnesium.

(e) Losses of calcium and magnesium were also highest when 4 acre-inches of water was applied twice per week in increments of 2 acre-inches.

Title: THE EFFECT OF SOIL TYPE AND MINERAL ADDITIONS ON THE MINERAL CONTENT OF TIMOTHY AND CLOVER

Leaders: G. P. Percival and D. Josselyn with the cooperation of K. C. Beeson, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York

Uniform treatments of fertilizer and lime were applied to experimental plots on a Gloucester fine sandy loam in 1948. The following year 2 and 5 pounds of cobalt, 50 pounds of nitrogen, 100 pounds of K_2O and 2 tons of lime per acre were applied to these plots as variables along with a uniform application of 5-10-10. The nitrogen and K_2O variable treatments plus the uniform 5-10-10 application were repeated for the following 4 years.

Samples of grasses taken at the end of the 5 year period showed that the 2 pound cobalt application no longer increased the cobalt in the grasses. In 1959 all plots except the 2 pound cobalt plots were sampled for timothy and witch grass. The 5 pound cobalt application still increased the cobalt content of the grasses greatly, but nitrogen decreased the uptake considerably and lime decreased it even more. The variables had no effect on the copper and zinc content of either timothy or witch grass. The timothy contained about twice as much cobalt as the witch grass and also contained more zinc but witch grass contained a greater amount of copper than timothy.

Title: COMPARATIVE LIFE HISTORY AND DISPERSAL OF *SITONA FLAVESCENS* AND *S. HISPIDULA*

Leader: William R. Lee

Previous work on this project has shown that the larval populations of *Sitona* spp. reach their highest peak in early June and a smaller peak in September. Only two species of adult *Sitona*, *S. hispidula* (F.) and *S. flavescens* Marsh., are found in appreciable numbers in white clover fields in New Hampshire. At present it is not possible to identify the larvae as to species; however, oviposition and emergence data have suggested that the larvae in June are predominantly *S. hispidula*, while the larvae in late summer and fall are *S. flavescens*.

During the summers, 1957 and 1958, the ratio of *S. hispidula* to *S. flavescens* was 2:1; however, during 1959 the ratio was 1:13. This change in relative abundance of the two species was presumably due to the previous severe winter with little snow cover. In 1959 the total larval population was less than in previous years, and, in contrast to previous years, the spring population was less than that in the fall. This is consistent with the theory that the June larval population peaks of 1957 and 1958 were predominantly *S. hispidula* while the fall populations were predominantly *S. flavescens*.

Scarcity of material during the 1959 season prevented work in the control room with S. hispidula or checking on the long maturation period previously observed in this species.

In conjunction with studies on the relation of Sitona larvae to root rot, 38 pots of white clover containing 20 eggs each of S. flavescens were placed in a control room at a temperature of 65±5° F. and 60 to 75% relative humidity. As in previous experiments only a small percentage of the eggs matured into adults; however, in 8 pots sacrificed on March 1, 1960, there were 8 adults of which three were teneral specimens indicating emergence within the last 24 hours. Of the remaining 5 adults, 2 were females that laid eggs when placed in an oviposition chamber. All of the 8 adults came from eggs laid October 22 to November 1, 1959; therefore, under these conditions S. flavescens requires about four months to complete its life cycle. This suggests only one generation per year in New Hampshire.

Title: DEFICIENCIES AND FACTORS IN FORAGE WHICH AFFECT THE ENDOCRINE SYSTEM OF DAIRY CATTLE

Leaders: P. A. Wright, H. A. Keener and F. E. Allen

Ladino clover's possible interference with reproduction is being investigated extensively in rabbits. Prefeeding Ladino for 2-3 weeks before mating, and continuing feeding during gestation results in complete infertility.

Shorter Ladino clover treatments (i.e., before mating only or following mating only) result in impaired fertility but not complete sterility. Ladino fed to immature rabbits does not appear to stimulate the reproductive tract prematurely, but does cause an abnormal distribution of cell types in the anterior pituitary gland. Further work is in progress to elucidate the way in which Ladino clover exerts its untoward effects on reproduction.

Studies to compare the possible effects of diethylstilbesterol and Ladino clover in the form of silage are being carried out with dairy cattle. Surprisingly high levels of estrogen activity have been found in fresh Ladino clover and in Ladino clover-grass silage during the past year.

NEW JERSEY (RUTGERS)

Title: GENETICS AND BREEDING OF FORAGE LEGUMES

Leaders: W. R. Battle, F. Olsen and L. Almodovar

In the study of inheritance of anthocyanin pigmentation in alfalfa, I_2 and $I_1 \times I_1$ populations showed marked reductions in vigor and seed-setting capacity. Flower production in some lines was greatly reduced, probably because of inbreeding depression. Resulting populations were too small for exact measures of gene number or mode of action, but apparently at least three pairs of genetic factors behaving in a quantitative non-dominant manner are involved. In the study of inheritance of feeding value, about 1200 plants representing high- and low-protein parents, their single-cross combinations, and their I_1 progenies were observed. Data were collected for individual plants on yield, dry matter percentage, leafiness, and date of maturity. Protein determinations have been completed on about 900 of the plants.

Title: FERTILIZER STUDIES WITH ALFALFA

Leaders: G. H. Ahlgren and J. L. Gerwig

The 1959 harvests represent the eighth year that this experiment has been under study. It is evident that potash is the key to high sustained yields together with superior persistence of the crop.

Nitrogen treatments ranging from none to 200 pounds per acre gave yields of 3.22 to 3.58 tons. Differences in yield were non-significant, showing that nitrogen applied to established alfalfa stands is essentially worthless.

In the phosphorus series ranging from none to 400 pounds per acre no response to this element has been obtained. The yields varied from 3.22 tons per acre to 3.52 tons. The soil apparently continues to have adequate phosphate supplying powers in spite of early soil tests showing only an average P_2O_5 content in the soil.

Strong response from potash continues, yields ranging from 0.60 tons per acre for no potash to 4.05 tons with 400 pounds of K_2O added each year. This is the fertilizer that must be emphasized in alfalfa production.

On the time of year for fertilizing alfalfa a single spring treatment was as good as another and a single fall application the least effective.

Table 1. The yield of alfalfa as influenced by different rates of K_2O with no nitrogen applied and P_2O_5 held constant.

Fertilizer applied yearly in March	Dry matter - tons per acre of alfalfa - 1959
0-0-0	0.48
0-100-0	0.60
0-100-50	0.85
0-100-100	2.38
0-100-200	3.22
0-100-300	3.66
0-100-400	4.05

Table 2. The yield of alfalfa as influenced by different times of fertilization.

Time of fertilization	Dry matter - tons per acre of alfalfa - 1959
None	0.46
Spring	4.17
First	3.19
Last	3.74
Spring - First	3.74
Spring - Last	3.96
First - Last	3.32
Spring - First - Last	3.79

Title: PASTURE RESEARCH

Leaders: R. W. Duell and H. E. White

The 1958-59 winter provided a stringent test for the hardiness of Midland Bermudagrass, however, its recovery at several locations in New Jersey was observed to be completely satisfactory. It was noted, however, that a September application of 800#/A of 10-10-10/A increased fall yields, but density of stand was reduced the following spring. This damage was overcome by continued high level fertilization during the growing season. The ability of this grass to use fertilizer was found to be greater than had been expected; when rates of 10-10-10 were increased to 1600#/A (applied 3 times per year) the yields increased in every instance over those from 800# applications.

None of the commonly used grasses were ever very satisfactory for pasture purposes in south Jersey's sandy Pine Barrens. With the introduction of Midland Bermudagrass, it appears that we have a species that will far exceed the commonly recommended grasses in permanence and yield, particularly during mid-summer when pasturage is most sorely needed. Midland Bermudagrass will not be recommended for general use until more is learned concerning its control.

For all practical purposes it may be said that Bermudagrass has 2-4 leaves per node. Well defined sections of 10 microns in thickness revealed no evidence of an internode between multiple leaves at a node. This characteristic may account in part for the high yields and dense foliage often associated with Bermudagrass. It should be mentioned in any description of the grass or in keys involving it. The multileaved node is not a characteristic of Bermudagrass, for it has been observed in other genera.

The grass fertilization studies are being expanded to include ratios of fertilizers and time of application as variables. Preliminary data indicate that grass species vary in their content of fertilizer elements and seasonal response in terms of yield. Using grasses that represent extremes in these characteristics, a better understanding of fertilizer ratios required and yield responses should be forthcoming.

The productivity of our summer annual grasses is generally good; however, it appears that attention to details such as earlier harvesting and higher height of cutting might increase the yields of regrowth and provide a more uniform distribution of pasturage. The advantage of leaving taller stubble was related to the location of growing points rather than to plant food reserves.

For the fifth consecutive year Wheeler sudangrass was the highest yielding entry in the sudangrass and millet variety trials, being far superior to Piper sudangrass under 3 times cutting to simulate grazing management. The pearl millets again recovered very poorly.

Title: PASTURE RENOVATION STUDIES

Leaders: R. D. Ilnicki, M. A. Sprague and R. W. Chase

Critical evaluations of cacodylic acid, dalapon and amitrol were made in all combinations and at several rates to determine their effectiveness for pasture renovation. Excellent kills were obtained using dalapon and amitrol or amitrol-T or cacodylic acid at 4 and 2 and 2 lbs. respectively. Reverse rates were not as effective. Some selectivity was recognized using cacodylic acid recognizing possible opportunity to remove bluegrass from old orchardgrass stands. Critical evaluations showed no advantage to separate and repeated applications using cacodylic acid. Date of treatment in relation to seeding date showed seedings of sudangrass should be delayed 10-15 days after application of the herbicide; waiting beyond this period was inadvisable due to regrowth and seedling weed problems. Activity of the herbicides was enhanced with high temperatures both before and after treatment in the greenhouse. In the field cacodylic acid activity was enhanced with the use of both cationic and anionic surfactants, particularly the latter. Field trials again confirmed earlier observations on the influence of eliminating competition of sod grasses on yield of summer annuals.

Title: THE DIGESTION OF GRASS HAYS GROWN UNDER DIFFERENT TYPES OF NITROGEN APPLICATION

Leaders: J. L. Evans, M. C. Stillions, and W. V. Chalupa

The hays used were second cutting alfalfa and three orchardgrass hays: (1) low conventional application--50 lb. N/A, (2) conventional application--100 lb. N/A, and (3) foliar spray--100 lb. N/A. The percentages of crude protein (dry matter basis) were 17.0, 11.0, 16.3, and 18.0, respectively. Alfalfa had higher (P .01) digestion coefficients for protein and NFE but lower (P .01) for crude fiber than any of the orchardgrass hays. Foliar applications of nitrogen increased (P .05) the digestion coefficients of protein and crude fiber over conventional nitrogen application. In other experiments when orchardgrass was substituted in varying amounts for alfalfa, digestion of alfalfa (20.2% protein):orchardgrass (11.1% protein) mixtures was linear to the proportion of hays fed.

Title: DEVELOPMENT OF LABORATORY METHODS FOR PREDICTING THE DIGESTIBILITY AND RATE OF CONSUMPTION OF FORAGES BY RUMINANTS

Leaders: J. L. Evans, R. E. Stoker, M. C. Stillions, and W. V. Chalupa

Objectives of this study are to measure the efficacy of in vitro cellulose digestion in predicting the nutritive value of forages, to determine the relationship between in vitro cellulose digestion and in vivo consumption, and to determine forage characteristics which affect their acceptability and rate of consumption by ruminants. Results from laboratory methods will be compared with other forage evaluation techniques.

Title: THE NUTRITIVE VALUE OF REED CANARYGRASS AS HAY WHEN GROWN WITH VARIOUS NITROGEN LEVELS

Leaders: W. V. Chalupa, J. L. Cason, and B. R. Baumgardt

In this trial the four hays fed were second-cutting alfalfa and three types of reed canarygrass: (1) 0 lb. N/A, (2) 100 lb. N/A, and (3) 200 lb. N/A. At the 200 lb. N/A rate, the reed canarygrass was equal or superior to the alfalfa in the digestibility of protein, crude fiber, ether extract, and energy and in percentage TDN. A correlation coefficient of +0.736 between TDN and DE was found. This relationship is expressed by the linear regression equation, $Y = 731.23 + 31.30\ X$ (Y = DE in cal./g.; X = TDN in %).

Title: HIGH NITROGEN GRASS PRODUCED BY HEAVY NITROGEN FERTILIZATION

Leaders: C. H. Ramage and C. Eby

Seven year old grass plots, established in the fall of 1952, continue to be highly productive. Considerably better yields were obtained in 1959 than in 1958, due largely to much higher third cutting response than usual. With supplemental phosphorus and potash applied as indicated by soil test results, orchardgrass and reed canarygrass plots in 1959 had yields as follows:

ORCHARDGRASS

	0# N	50# N	100# N	150# N	200# N	300# N	400# N	600# N
D.M., lbs./acre	4200	5300	6350	7450	8150	8600	9000	9050
Protein, %	12.01	14.04	13.94	14.06	16.93	18.30	20.27	20.45
Protein, lbs./acre	503	747	885	1046	1380	1574	1829	1847
% N recovery	----	78.1	61.1	57.9	70.2	57.1	53.0	35.8

REED CANARYGRASS

D.M./lbs./acre	4200	5550	6600	7400	8650	9750	10,250	9900
Protein, %	12.52	14.18	14.09	14.16	16.74	19.92	22.65	23.56
Protein, lbs./acre	525	785	931	1051	1445	1947	2318	2330
% N recovery	----	83.2	65.0	56.1	73.6	75.8	71.7	48.1

Title: VARIATIONS IN FORAGE INTAKE DUE TO ANIMAL DIFFERENCES

Leaders: R. E. Mather, P. F. Randel, K. O. Pfau, and J. W. Bartlett

The objective of this study is to determine the permanence of a cow's relative appetite for forage (repeatability) and the degree to which the differences in appetite may be transmitted to the offspring. Trials with milking cows showed a week-to-week repeatability of .64 for 1958-59, which was in line with previous estimates for periods within the lactation. Estimates with heifers were .54 on a within-sire within-year basis. Heifers also seemed to retain their relative appetite rank from year to year as shown by a repeatability of .55 with eight heifers. The degree to which these differences are inherited cannot be measured with accuracy at present because of small numbers. However, the indications are that cows with an appetite for more forage may be selected and this characteristic will be transmitted to the offspring to a practical degree.

Title: SILAGE INVESTIGATIONS

Leaders: M. A. Sprague and L. Leparula

Studies were undertaken in 2-ton experimental silos to determine the influence of agronomic variables on efficiency of preservation of forage species as silage. Essentially pure stands of seven species, some harvested at two maturities, were ensiled in duplicate silos. Determinations were made of losses of surface, total dry matter, and protein and measurements of quality of the ensiled forages (without use of a preservative) were made as per cent volatile acids, volatile bases, odor, pH, color and appearance. Species included were barley, oats, alfalfa (early and late), sorghum, orchardgrass, bromegrass and corn (early and late).

No surface spoilage was observed which aided greatly in reducing experimental errors. Seepage losses were obtained only when the forage was ensiled at about 26% dry matter in alfalfa. All dry matter losses measured were below 10% except oats harvested at the early bloom stage of growth which expressed 13% total dry matter loss. Corn in milk and dent stages of maturity preserved equally well (4.2 and 4.4% DML) whereas late (early pod stage) alfalfa preserved better (2.3% loss) than alfalfa in the very early bloom stage (6.3%). Orchardgrass and bromegrass preserved about the same (6.7 and 6.9% loss) as those listed above. Barley cut when just out of the boot suffered 9.4% loss.

These data indicate some variability between species and maturities may exist although they are small by comparison to the losses experienced from other causes on farms. It is intended to repeat most of these trials for verification during another season.

NEW YORK (CORNELL)

Title: BIRDSFOOT TREFOIL BREEDING AND GENETICS

Leaders: P. R. Henson, R. R. Seaney, and D. Gershon (ARS, USDA in cooperation with Cornell University, Ithaca, New York)

The amount of self-fertilization occurring when cross-pollinating without emasculation has been determined for 8 clones of L. corniculatus. Cyanogenesis or positive HCN reaction was used as a dominant genetic marker to distinguish between "self" and "cross" progeny. The following table shows the amount of selfing which occurred when plants were crossed without emasculation. Also, listed for each clone are the number of progenies tested and the self-fertility of each clone as expressed in terms of the number of seeds set divided by the number of flowers pollinated.

Clone Number	Self-Fertility Seed/Flower	Number of Plants Tested	Percent Selfing When Cross-Pollinating
7-9	.16	287	0
8-12	.2	442	2.7
80-2	3.3	3598	1.6
522-10	5.0	1729	11.0
523-10	2.2	723	3.6
525-4	.92	724	4.8
526-4	2.8	520	3.6
651	7.6	1804	73.7

Note that the relatively self-sterile clone 8-12 set 3 percent self-seed when cross-pollinated without emasculation. Cross-fertility with the marker parent was similar for all clones. Date of crossing had no effect on the amount of self- and cross-fertilization. These results indicate that when making crosses, even between self-sterile plants, emasculation should be used to assure that the required cross is obtained.

First year results indicate that self-fertile plants of L. corniculatus set as high as 30 percent self-seed under normal field conditions.

Cyanogenesis has been used as a marker for the identification of hybrids from the crosses L. corniculatus x L. tenuis and L. lamprocarpus x L. corniculatus. Hybrid progenies have also been obtained from the crosses L. corniculatus var. japonicus x L. divaricatus, L. corniculatus var. japonicus x L. filicaulis, and L. corniculatus var. japonicus x L. tenuis. All of these interspecific hybrids have been propagated, and studies will be made of chromosome homology, cross- and self-fertility, and inheritance of plant characters.

Inbreeding of L. corniculatus has advanced to the S_3 generation. Preliminary results indicate a 50-60 percent reduction in dry weight yield from the S_1 to the S_2 generation. Under field conditions, seed set of the S_2 is about 60 percent of that in the S_1 generation.

Frequencies of HCN negative plants have been determined for the following varieties: Viking, 2.5%; Empire, 0%; Mansfield, .5%; Granger, .9%; a lot of imported European, 1.3%; L. tenuis (New York), 11.7%. From 1800 to 2600 plants were tested for each variety.

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS OF NEW YORK

Leaders: R. P. Murphy, R. E. Anderson and C. C. Lowe

(Refer to 1958 Annual Report, page 99)

Alfalfa: The maintenance and evaluation of second-cycle clones were continued.

The backcross breeding program to add resistance to bacterial wilt to Narragansett and to the Flemish types is being continued. A rather high degree of resistance seems to be present in the third backcross generation (93.75 percent recurrent parent).

The selection program of increasing the seed production of Narragansett has been expanded. The clones originally selected in Wyoming were re-established from cuttings in a seed trial test at Riverton, Wyoming, by Dr. William Riedl. The high producing clones were notably higher in observed seed set than the unselected Narragansett used as a check and the low producing clones were again very low in observed seed set. A selection for increase and probably release is being developed from 25 parental clones selected from the high seed group of 100 clones (50 from Wyoming plus 50 from California). These clones were selected on the basis of (1) high seed production when outcrossed by hand in the greenhouse, (2) relatively low seed production when selfed by hand in the greenhouse, and (3) the performance of their progenies for forage production when tested in the field at Ithaca.

Creeping-rooted plants in F_4 progenies showing excellent seedling vigor have been selected for upright, vigorous growth habit; the resulting intercross populations will be planted in space-planted nurseries in 1960. Two groups of F_4 progenies planted in a favorable location scored an average of 64 percent creepers after one year in the field. The excellent characteristics of F_3 X Flemish progenies give promise of combining better seedling vigor with the creeping habit. Three selections of creeping material are being increased under cage during 1960.

A detailed study of the inheritance of the creeping-rooted habit is currently in progress. Four different creeping clones and several non-creeping clones with characteristic growth habit or flower color are being studied as cuttings, selfs, intercrosses and backcrosses.

The morphological and cytological responses of alfalfa seedlings and mature plants to X-ray and thermal neutron treatment of dormant seed are being studied. During early stages of development, seedling heights were decreased as the treatment dose increased; growth response was more uniform within any treatment level in the material subjected to thermal neutrons. No effect was found on mature plant height or on variation in flower color; however, vigor of the treated plants was lessened as dose increased. Cytological

study of root tip cells showed that the common chromosome aberrations were dicentric chromosomes and acentric fragments. The frequencies of abnormal mitotic anaphase cells increased approximately proportionally to the dose of the radiation. In meiosis the percentage of cells containing lagging chromosomes increased slightly with the higher doses in both telophase I and telophase II. The proportions of abnormal pollen grains also were increased.

A study of self-fertility in diploid Medicago falcata was completed. Four S_1 families, ten F_1 families, and sixteen backcross families derived from five self-sterile plants were investigated. This study was carried out by Jonas Miller and part of the investigations were made while he was a pre-doctoral student at Brookhaven National Laboratory. Most progenies were as self-sterile as their parents--no true self-fertile plants were obtained. Crosses among sibs could be grouped into three major categories--sterile, fertile, and semi-cross-fertile. Semi-cross-fertility, the percentage of seeds per flower using the testcross as a frame of reference was a highly consistent characteristic of related matings. Backcrosses and intercrosses rarely segregated distinct genotypes. Self-sterility in M. falcata appears to be the result of two phenomena: (1) incompatibility and (2) early abortion following fertilization. Self-incompatibility apparently is physiologically independent of post-fertilization failure. It is suggested that self-incompatibility in diploid M. falcata is conditioned by a two-gene gametophytic system. Conceivably these genes have resulted from a duplicated locus and the competitive interaction of two different S alleles in a single pollen grain permits self-fertility which is masked by varying degrees of post-fertilization abortion.

All possible single-crosses were made within several groups of selected clones for both orchardgrass and timothy. Muslin covered cages were used to effect the crosses under field conditions. Very favorable results were obtained. Progenies will be studied in the field to trace the inheritance patterns of desirable characters.

Title: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy and A. A. Johnson

(Refer to 1958 Annual Report, page 104)

Testing of stock seed lots of DuPuits alfalfa from France and Alfa from Sweden is being continued in order to check their genetic purity. These lots have all proved to be satisfactory.

Continued evaluation is in progress for polycross progenies of bromegrass clones originating as selections in a second cycle of breeding for this species at this location. These were tested under two cutting managements; one has now eliminated stands for many progenies. It appears obvious that in a species so responsive or susceptible to management variation extreme care must be given to management details in conducting performance trials.

Progeny evaluation of clones from a second cycle of selection is also in progress for orchardgrass and timothy. In the population of orchardgrass there still appears to be a strong relationship between earliness in maturity and amount of heading for seed production. This has been very serious in previous selection efforts for later orchardgrass. Color and leafiness can probably be improved on but none of the current clones appear to give progenies which are both very late and profuse headers.

Improvements in heading and seed production as well as in height and culm strength appear to be present in second cycle timothy progenies. Some of these are also very promising for better color and leafiness.

Seed increases of synthetics and hybrids in bromegrass, orchardgrass, timothy and alfalfa are being made in New York in connection with the regional project, NE-28. Through cooperative testing between states in the Northeast, nearly all advanced breeding materials now have regional rather than single-station status. As such, they are listed as being included within the regional project even though selection, early testing and much of the cost of maintenance and increase is still borne by the originating station.

Cooperative testing is in progress with the U.S.D.A. on single crosses from a number of alfalfa clones collected throughout the United States in combination with two good combining clones from New York. These single crosses have shown a tendency for remarkable uniformity for plant type, color, and disease resistance but to date have not indicated any large yield advantage over adapted varieties. Some of these characters appear to be transmitted rather consistently by the two New York clones over a wide range in genotypes represented by other clones used in the single crosses.

Cooperative testing is also in progress with the U.S.D.A. on variety crosses and blends in alfalfa in comparison with the parental varieties.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MID-SUMMER DROUGHT

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson, and H. A. MacDonald (Agronomy) cooperating

(1958 Annual Report, page 100)

Increased emphasis is now being placed on quality of forage in conjunction with production in determining the potential of new varieties. Evaluation of new and current varieties and mixtures in the important agricultural areas of New York is being continued. Trials designed to identify interactions of forage varieties with various production factors such as cutting, management, mixture and companion crop competition, and fertility levels are in progress to determine the optimum conditions for obtaining maximum expression of genetic differences in forage production, distribution and quality.

Alfalfa: As rapidly as seed supplies permit, the newer varieties--Narragansett, Vernal, DuPuits and Alfa--are replacing Ranger which has predominated in usage for nearly 10 years in New York. The above varieties have continued to be superior under certain prescribed environment and management conditions (see 1958 report).

The winter of 1958-59 provided the most severe winter conditions in many years for loss of stands over winter. Considerable killing was observed in stands two years or older while new seedings showed little damage. The difference among adapted varieties in survival was small. The killing seemed to be somewhat at random. Ice sheeting and desiccation both seemed to be involved and probably varied from area to area.

Considerable test information has now been accumulated on the Swedish variety, Alfa. Performance has been similar to that of DuPuits.

Extensive tests and demonstrations are being planted this spring (1960) for the final evaluation of N.Y. Synthetic A, N.Y. Synthetic B, a high seed production selection of Narragansett, a wilt resistant selection of Narragansett, and a wilt resistant selection of the Flemish type.

Orchardgrass: A series of extensive trials comparing the productiveness of synthetics of different maturity under several managements and associations is still in progress. Composition of mixtures (and ultimately yield) has been markedly affected by differences in grass competition, cutting management and drainage variations within the trials. Timothy and bromegrass are included in these tests.

Timothy: Extensive trials are in progress to determine the production and quality differences between varieties harvested at weekly intervals throughout the period of the first harvest. A few varieties of alfalfa, birdsfoot trefoil, bromegrass and orchardgrass are included. Dry matter content of forage at harvest is being critically examined as an indicator of forage quality. The percent of dry matter increases at approximately the same rate as the percent digestibility declines as the date of first harvest is delayed from about June 1. Experiments to date show consistent variety differences in timothy for these characters. The percent of dry matter can be measured with great accuracy. The coefficients of variation of the dry matter determination on grasses have been consistently less than three percent. The comparison of dry matter content of early and late timothy varieties with animal evaluation of the forage has indicated a close relationship in preliminary trials between lower dry matter and higher value as feed. Extensive investigations are in progress. Preliminary results indicate a very substantial increase in both digestibility and intake for Essex, a late variety of timothy, versus common when grown and harvested under the same conditions in early July.

Bromegrass: Evaluation of this species has shown Saratoga to be superior to Southern type varieties in vigor, establishment, and aftermath production. Trials have shown that it should be grown with the best and most vigorous alfalfa varieties. With a less competitive variety like Ranger, it has been demonstrated that the additional vigor and competitiveness of Saratoga may work as a detriment to the legume stand and the mixture yield.

Hay and Pasture Grasses: Some work is being continued on comparing the more promising strains of tall oatgrass, tall fescue, reed canarygrass and ryegrass with the more commonly used grasses previously discussed. In a comparison of these at one location under several managements, associations, and nitrogen levels, preliminary results showed a more marked response to nitrogen when these grasses were grown in mixture with alfalfa and Ladino clover than when they were grown alone.

Annual Forages: Production capabilities of a number of annual forages including varieties of millet, sudangrass, forage sorghum and a sorghum-sudan hybrid were compared with drilled corn in 1959. Good production was obtained in this exceptionally hot summer on nearly all species. However, results to date indicate that any superiority over corn would probably not be in yield but in some other agronomic or cultural advantage or preference. Samples of these forages were collected for animal feeding trials in order to measure digestibility and intake.

Title: A STUDY OF THE SOURCES AND CONTROL OF NUTRITIONAL LOSSES OCCURRING DURING THE HARVESTING AND STORAGE OF HAY AND SILAGE

Leaders: W. K. Kennedy and M. J. Wright

When air was excluded immediately after the ensiling of samples, there was a rapid buildup of lactic acid and drop in pH. In aerated samples the bacterial buildup was delayed and the silage produced was of poor quality. Laceration did not improve the preservation of aerated silage.

Hand-separated grass and alfalfa were recombined in desired proportions and ensiled. Silages made from pure alfalfa were low in lactic acid, high in acetic, and contained traces of butyric. Lactic acid content of the silage was inversely related to pH and decreased almost linearly as the proportion of alfalfa increased. Wilted silage of 100% alfalfa, though high in pH and only moderately high in lactic acid, was judged superior in color and odor to similar but unwilted material.

Title: INFLUENCE OF DATE OF CUTTING, NITROGEN FERTILIZATION, AND IRRIGATION UPON THE YIELD AND DIGESTIBILITY AND INTAKE OF DIFFERENT FORAGES BY RUMINANTS

Leaders: W. K. Kennedy, J. T. Reid, and M. J. Wright

Investigations of nitrate poisoning were continued with dairy cattle. Methemoglobin responses to hay sprayed with nitrate indicated that presently accepted levels of toxicity are too low. The LD_{50} (dosage lethal to half of the test animals) should be set near 45 gms. NO_3^- per 100 lbs. live weight, rather than 15 gms., if the nitrate is ingested in forage. The discrepancy appears to trace to the manner or rate of administration of nitrate. The 15-gm. level was established by drenching, and was confirmed by drenching animals in the present experiments at Cornell, but this procedure is not representative of field conditions.

Short-term feeding of dairy cattle with oat hay produced neither death nor adverse sublethal effects even though the nitrate content of the hay and daily rate of ingestion greatly exceeded current safety standards.

Urea and ammonium nitrate were applied in fall or spring to two orchardgrass and two timothy meadows at 60, 120, and 180 lbs. N per acre. No significant difference between carriers was obtained; increases in yield produced by fall applications were about 85% as great as those produced by spring applications, as opposed to about 60-70% in earlier studies.

Title: BIOCHEMICAL AND MICROBIOLOGICAL STUDIES OF GRASS SILAGE

Leaders: P. C. Kearney and W. K. Kennedy, Cornell University, Ithaca, New York

Experiments were conducted to determine what effect air played during the early hours of the silage fermentation process. When the air was immediately excluded from the silage, there was a rapid build up of the lactic acid bacteria with a concomitant drop in pH and formation of lactic acid. If the forage was aerated for periods of time as short as six hours, bacterial build up was delayed and the subsequent silate was poor in quality as judged by conventional standards. It appears that lacerating the aerated material had no beneficial effect on the resulting silage.

Another group of experiments was set up to determine why pure alfalfa often is so difficult to ferment. Various mixtures of grass and legume were ensiled under similar conditions. Those samples that were composed of pure alfalfa were low in lactic acid, high in acetic acid, and contained slight traces of butyric acid. Pure grass, however, was strongly acidic and made excellent silage. The lactic acid produced in the various percentage mixtures of grass and alfalfa was inversely related to the pH of the silage and showed almost a linear decrease with increasing concentrations of alfalfa. Further experimentation showed that the buffering capacity of pure alfalfa may represent one reason for the difficulty offered in attempting to ensile direct cut stands of pure alfalfa.

Finally it was shown that if the forage which contained 100% alfalfa was wilted to successively higher contents of dry matter, that the resulting silage had a very pleasant odor, maintained its green color, and by all other standards was judged to be of excellent quality. It is interesting to note that this wilted silage was high in pH and contained only moderate amounts of lactic acid.

Title: A CRITICAL EVALUATION OF LEVELS OF NITRATE IN FORAGE THAT ARE TOXIC TO DAIRY CATTLE

Leaders: R. F. Crawford and W. K. Kennedy, Cornell University, Ithaca, New York

The objectives of this study were to investigate the validity of the presently accepted lethal levels of nitrate in forage, and to investigate the possibility of adverse sublethal effects of nitrate in forage on dairy cattle.

Feeding trials with yearling dairy heifers demonstrated that the lethal level LD_{50} of nitrate in forage was about three times the presently accepted LD_{50} of 15 gm. of NO_3/cwt. of animal. The same animals were later given nitrate

as a drench; the results were comparable to the presently accepted LD_{50} established by administering nitrate with a stomach tube. It was concluded that the difference in results was due to the slow rate of intake of nitrate in forage compared to nitrate given as a drench, capsule, or even mixed in grain. This difference in experimental method was found to be so significant that accepted levels of nitrate that will cause adverse sublethal effects are completely invalid. Feeding trials with nitrate in forage did not cause abortion, loss in milk production, or loss in weight of dairy cattle when the level of nitrate in forage was even greater than currently accepted lethal levels. Considerably higher levels of nitrate in forage can be tolerated than levels established by experimental workers who used drenches, stomach tubes, or grain to administer the nitrate. Further work is needed to establish the levels of nitrate in forage that will cause adverse sublethal effects, especially for long periods of feeding.

Title: STUDIES ON RESPONSE OF LEGUMES TO MOLYBDENUM AND LIME FERTILIZATION ON MARDIN SILT LOAM

Leaders: W. M. Kliewer and W. K. Kennedy, Cornell University, Ithaca, New York

Greenhouse experiments were conducted on virgin Mardin silt loam with birdsfoot trefoil, alfalfa, Ladino, and medium red clover at different rates of lime in the presence and absence of molybdenum. Data include yields, percent N, and Mo content of both the plant tops and roots. Responses to Mo were obtained in the absence of lime and in the presence of lime up to 1 ton per acre. At 2 tons of lime per acre and above, there was little to no response to Mo. Birdsfoot trefoil showed the greatest response of the four legumes studied. A relationship existed between soil pH and Mo content of the plant material. Mo influenced the color, yield, and N content of forage and the size and distribution of nodules. Data indicated that when lime was applied at a rate of 2 tons per acre or greater, it had an additional effect besides increasing the availability of Mo, or P, or providing a suitable environment for Rhizobia bacteria. This was especially true for alfalfa and to a lesser degree for birdsfoot trefoil and the clovers.

Title: MAXIMUM UTILIZATION OF FORAGES BY LIVESTOCK

Leaders: S. T. Slack, K. L. Turk, G. W. Trimberger, J. I. Miller, J. T. Reid, D. E. Hogue and J. K. Loosli (Department of Animal Husbandry) and W. K. Kennedy and H. A. MacDonald (Department of Agronomy)

In previous experiments with lactating cows more milk per pound of dry matter intake has been obtained from wilted silage than from barn-dried hay (unheated air) cut on the same day. These data will be published in the spring of 1960. Experiments are now in progress to determine the basic reasons for the differences observed in dry matter utilization.

Experiments are now in progress to determine the basic reasons for the differences in value between early-cut and late-cut forage.

Yearling dairy heifers and lambs were fed early- and late-cut hays both free choice and paired to equalized intakes. Also, protein and/or estimated net energy were equalized in some groups. This experiment was designed to measure the quantitative differences in the hays due to intake, energy and protein. The observed differences were small and the trial will be repeated before definite conclusions can be justified.

An experiment to compare the quality and feeding value of birdsfoot trefoil and a legume-grass mixture harvested for hay by different methods at different stages of maturity was conducted for the second year. Average daily milk production from the first year test were: early, first cutting, birdsfoot trefoil, 52.5 lbs.; early, first cutting, legume-grass, 50.4 lbs.; late, first cutting, birdsfoot trefoil, 43.2 lbs.; second cutting, birdsfoot trefoil, 50.4 lbs.; and second cutting, legume-grass, 48.6 lbs. Results for the second year are following the same pattern.

Title: BIRDSFOOT TREFOIL INSECT INVESTIGATIONS

Leaders: R. L. Ridgway and George G. Gyrisco

Because of its importance in birdsfoot trefoil seed production emphasis was placed on the biology and control of the tarnished plant bug. In the laboratory the rate of development of the different stages of the tarnished plant bug was determined at several different temperatures. In the field weekly collections were made in several locations. From these weekly collections it was possible to determine that there are 3 generations of the tarnished plant bug in New York. Information was also gathered on the sex ratio and the number of eggs possessed by females. Studies of the height of flight indicated that 90 percent of the tarnished plant bugs fly within 6 feet of the ground. Studies of the damage caused to birdsfoot trefoil by the tarnished plant bug were continued.

In control studies, treatments with aldrin, parathion, DDT, and toxaphene significantly increased seed yields from birdsfoot trefoil when applied in mid-June to control the tarnished plant bug. These increases in seed yields resulted in plots where tarnished plant bugs averaged 16 or more in 25 sweeps. Of a number of relatively new materials tested for tarnished plant bug control, Dimethoate, Dibrom, Methyl-trithion, and Dylox, proved to be especially effective when applied at the rate of 1.0 pound per acre.

In studies with other insects, control of the meadow spittlebug increased hay yields but failed to increase seed yields. However, populations were at a lower level than in most years. Taxonomic studies of the genus Bruchophagus continued, and a tentative key to the genus was prepared.

A technique was developed whereby the seed yield from birdsfoot trefoil could be estimated in pounds per acre from square foot legume counts.

Title: FORAGE INSECT INVESTIGATIONS

Leaders: H. Y. Forsythe, Jr. and George G. Gyrisco

Seasonal insect population fluctuation: The meadow spittlebug adults reached a peak abundance about the last of June, and the potato leafhoppers reached a peak sometime in August or the first of September. The tarnished plant bug adults appeared to have two and possibly three peaks of abundance on alfalfa and red clover during the 1959 season.

Forage seeding insects: During the fall survey, P. leucophthalmus (Linn.), E. fabae (Harris), E. inimica, M. fascifrons (Stal.), L. lineolaris (P. de B.), P. politus, N. ferus (L.), and M. pisi (Harris) were collected in large numbers by sweeping legume seedings, after the grain nurse crop had been cut.

Potato leafhopper control: Methoxychlor and Dimethoate emulsions, each at 1.0 pound per acre, proved consistently to be the only effective insecticides for leafhopper control on alfalfa. Dimethoate seemed to show better control than methoxychlor after 14 days.

Clover root borer control: Heptachlor and Shell 4402, each at 1.0 pound per acre, proved to be effective granulated materials for the control of the clover root borer on red clover. Shell 4402 showed complete control of the insect.

Alfalfa snout beetle control: Granulated dieldrin applied to alfalfa in 1957 at 3.0 and 5.0 pounds per acre still showed effective control of the snout beetle larvae. Dieldrin at 1.0 pound per acre might possibly have lost some of its residual action.

In another experiment granulated dieldrin at 5.0 pounds per acre, applied to alfalfa in 1956, seemed to show the best control of the larvae, while dieldrin at 3.0 pounds, aldrin at 5.0 pounds, and heptachlor at 5.0 pounds also significantly reduced the number of snout beetle larvae.

Title: SITONA WEEVIL INVESTIGATIONS

Leaders: H. Y. Forsythe, Jr. and George G. Gyrisco

Under controlled field conditions, S. hispidula (Fabricius) females laid most of their eggs on the soil surface, in soil cracks, and around the plant crown of a legume plant. Some eggs were also laid on the plant foliage.

Under lab conditions, spring-collected clover root curculio females laid an average of about 128 eggs. The males lived for a shorter period than the females in this study.

Clover root curculio eggs hatched in 15.3 days at 68° F. and in 9.9 days at 77° F.

The peak abundance of the larval and pupal stages of S. hispidula around Trifolium plants appeared to come sometime in June. Pupae, callow adults and large larvae were usually found within one inch of the soil surface, although some pupae were found down as far as three inches.

The clover root curculio pupal period averaged 9.3 days at 77° F., 15.1 days at 68° F., and 25.7 days at 59° F.

Many S. hispidula adults were found in October sweeps in forage legume seedings after the grain nurse crop had been cut, whereas only an occasional adult was found in September sweeps. S. flavescens (Marsham) adults were also found to follow a similar pattern.

In sweeps in forage legume fields throughout the 1959 growing season, most clover root curculio adults were collected in sweeps in May, the last of September and October.

Light root injury caused by larval feeding was found in two first cutting-year alfalfa fields.

Title: BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL

Leaders: George O. Poinar, Jr., G. Levesque and George G. Gyrisco

Eggs of the alfalfa weevil were first found this year on May 9, in a field in Dutchess County. In general, the majority of egg laying occurred in the spring and early summer. A slight increase in egg laying was observed late in the summer in one of the fields. Since new weevils that were collected from the field in August deposited viable eggs, it is possible that the increase in number of eggs found in the field in late summer is the beginning of a second generation.

Alfalfa weevil larvae were first found this year on April 25, but the populations did not build up until around the middle of May. The larval peak occurred around the first of June, and the numbers began to slowly decline until around the first of July when they dropped off quite rapidly.

The peak of new adults occurred in late June. Shortly after this date, the adult numbers dropped off quite rapidly. This decrease in numbers is probably due to natural mortality of the adults and to their movement out of the field.

Square foot sampling in one field showed a noticeable decrease in adult numbers over the period from the first to the middle of July.

Square foot sampling in and out of the fields showed that during the period from July 16 to September 10, almost twice as many adult alfalfa weevils were found outside the alfalfa field as were found in the field.

The adult weevils change their behavior over a 24 hour period. Toward evening, they begin climbing to the top of the alfalfa plants and start feeding. This activity lasts all night. As dawn approaches, the majority of adults retreat back to their daytime habitat and remain fairly inactive in the trash or under leaves on the lower portion of the plants. This behavior seems to be best correlated with light intensity.

The larvae, on the other hand, feed day and night and don't show this variability in their behavior.

A study of the quantitative changes of nitrogenous compounds in alfalfa plants over a 24 hour period by paper chromatographic techniques showed that certain compounds in the plant are present in greater amounts during the day than at night and vice versa. It was considered that light may have indirectly affected the weevil behavior through changes in the chemistry of the alfalfa plant.

There appear to be 4 larval instars of the alfalfa weevil. The complete larval development of the weevil lasts around 11 days at 27° C.

Under insectary and field conditions in mid-June, the average cocooning period of the alfalfa weevil was around 14 and 15 days respectively.

The adult weevils have a wide range of host plants and apparently can obtain nourishment from plants like tobacco and Bryophyllum. The larvae are much more restricted in their feeding habits. However they were able to complete their development on black medic, white clover, sweet clover, and vetch.

Several new parasites of the alfalfa weevil were discovered this year. An Ichneumonid, Gelis was found as it emerged from a pupa of the alfalfa weevil. A dipterous parasite was discovered as it emerged from the larva of the alfalfa weevil or the clover head weevil; (Hypera meles Fab.). It was identified as Leucostoma simplex (Fall.).

A nematode parasite of the alfalfa weevil was found this year. As many as 12 out of 42 fourth instar larvae collected from a field were found to be parasitized by nematodes.

Control:

1. Four replicated experiments, totaling 144 plots, were conducted on 2nd and 3rd cutting alfalfa fields in Dutchess and Orange Counties in 1959. Nine emulsifiable insecticides, 1 nematocide, and 1 flowable formulation were applied with a low-pressure weed sprayer. Heptachlor was used as a standard in all the experiments, giving excellent larval control till harvest. Shell-SD 4402 at 4 ozs. and 2 ozs. of actual toxicant per acre gave very good results. The other materials applied--Methyl-trithion, phosphamidon, dimethoate, Geigy-30494, and thiodan--did not show much promise for larval control.

2. Attempts to gain information on the chemical control of the alfalfa weevil adults with emulsifiable insecticides were almost fruitless due to an unprecendented migration of the adults to nearby surrounding environments. Nematocide 18133 at 16 ozs. of actual toxicant per acre gave the best results, but the results were not significant due to extremely low numbers of adults.

3. Some evidence has been gathered which shows that adults may migrate to shaded areas in the late summer in New York. One field where evidence was collected produced, for an equal number of samples, 61 adults outside the field and 4 adults in the field.

4. No weevil adults were caught in tanglefoot traps set out in late mid-summer to see how and when migration took place, although some adults were collected outside the field in square-foot soil samples.

5. No new counties were found infested with the alfalfa weevil in a survey conducted in 1959. Therefore, 14 counties, as in 1958, are known to be presently infested with this pest of alfalfa.

PENNSYLVANIA

Title: THE NUTRITIVE VALUE OF GRASS SILAGE AS AFFECTED BY SPECIES AND STAGE OF MATURITY

Leaders: J. B. Washko, J. W. Bratzler and E. Keck

Two corn hybrids, Pa. 602 and dwarf 602 and two forage sorghums, Black Amber and hybrid R. S. 301 F. were compared for silage production when harvested at different stages of maturity. Pa. hybrid 602 outyielded dwarf 602 when harvested at the milk and early dent stages of maturity. Both hybrids, however, yielded approximately the same amount of silage at the glazed stage.

Forage sorghum R. S. 301 F. outyielded Black Amber by approximately .8 tons of dry matter. Neither forage sorghum was as productive of silage as either hybrid corn. At the glazed stage of maturity the two corn hybrids produced approximately 6.78 tons of dry matter per acre as compared with the sorghums which ranged from 3.86 to 4.68 tons of dry matter when harvested at the medium dough stage of maturity.

Hand separations of the two hybrid corns indicated the following: that dwarf 602 when compared with its tall 602 counterpart contained more leaves, more husks, more cob and less stalks.

The nutritive value of the silage made from these corn hybrids and forage sorghums as determined by feeding trials with sheep have not been completed.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leaders: J. B. Washko, F. W. Peikert, and J. K. Pasto

Yield data were collected for the 7th consecutive year on this experiment at University Park. Viking birdsfoot trefoil continued to be higher yielding than Empire trefoil under both grazing and hay management in grass association. Under grazing managements Viking trefoil and reed canarygrass was the highest yielding combination. Yields averaged 1.96 tons per acre in the 7th harvest year. Empire birdsfoot trefoil with smooth bromegrass was next most productive under grazing management with a seasonal yield of 1.80 tons of dry matter per

acre. Under hay management both Viking and Empire varieties were most productive in association with timothy, the former yielding 2.86 tons and the latter, 2.46 tons per acre, respectively after 7 years of harvest.

Considerable winter killing of the birdsfoot trefoil occurred during the winter of 1958-59, hence the productivity level of all species combinations dropped in 1959 as compared with previous years.

Title: PRODUCTIVITY AND LONGEVITY OF RENOVATED PASTURES

Leaders: J. B. Washko, J. K. Pasto, and D. A. Mays

A small plot pilot experiment to study the possibility of stock-piling birdsfoot trefoil forage for mid-summer grazing was initiated in 1959. In this experiment, simulating various grazing systems, the forage was removed mechanically. The following ten treatments were compared for production of quality forage throughout the summer months: rotational grazing management; stockpiling of initial growth until June 15, July 1 and 15, followed by a second harvest when the forage was 8 to 10 inches in height; removal of the first harvest for silage on June 3 and June 15 followed by stockpiling until August 1, August 15 and September 1.

The yields of dry matter and total digestible nutrients (T.D.N.) increased at first harvest until July 1 after which there was no increase. There was, however, a gradual decline in T.D.N. content during this period. The highest yields at the second harvest were associated with the longest periods of growth between 1st and 2nd cuttings. Early harvesting (June 3 or 15) was very effective in making good yields of high quality forage available in August. Even when this forage was stockpiled until September 1, it contained approximately 60% T.D.N. Most of these treatments resulted in a third harvest of forage in mid-September. The greatest seasonal yields of dry matter and T.D.N. were realized from plots which were initially harvested on June 15 or July 1, harvested for the second time in early or mid-August and for the third time in mid-September.

Title: EVALUATION OF GRASSES AND LEGUMES FOR HAY, GRASS SILAGE, AND PASTURE FOR DAIRY COWS

Leaders: J. B. Washko, P. S. Williams, A. L. Haskins

The influence of nitrogen fertilization on the productivity of two summer annual species under grazing was studied. Prior to seeding the paddocks, 500 pounds per acre of 0-15-30 fertilizer was worked into the seedbed. Nitrogen at 200 pounds per acre was applied prior to seeding in one application and in split applications of 50 pounds each. The split applications of N were made just before seeding and after each of 3 grazings. Piper sudangrass and Gahi hybrid millet were the species grazed in rotation by dairy cattle.

Piper sudangrass was more productive than Gahi millet. Gahi millet also proved to be less palatable, as indicated by percentage of forage consumed. Only 64.2% of Gahi millet produced was consumed, as compared with 81.6% for Piper sudangrass. Piper sudangrass furnished 284 cow-days of grazing in contrast to 260 for Gahi millet. One additional rotational grazing was furnished by Piper sudangrass, as compared with Gahi millet.

There was no advantage in yield, carrying capacity or number of grazings from splitting the N applications in this grazing experiment over applying all the N at one time.

Title: AN INVESTIGATION OF ALFALFA CROWN ROT

Leaders: H. B. Couch, J. L. Starling, and R. W. Cleveland

The primary fungus pathogens concerned with alfalfa crown rot having been identified in the previous years' investigations, emphasis was placed on the development of techniques for studying the role of the various facets of the environment on disease development. To this end, using the tomato plant as the test species and the root knot nematode as the test pathogen, a split-root technique was developed that allowed the study of root disease development under conditions of continuous permanent wilting percentage soil moisture stress in the presence of an intact, living root system. With this background, special containers have been constructed and alfalfa plants are now being grown for the purpose of studying the influence of soil moisture, in the readily available range, on root and crown rot.

The above-mentioned technique has been further refined to allow simultaneous studies of the influence of soil moisture and soil temperature on root and crown disease development.

A final experiment has been established to conclude the study concerned with the determination of the cause of crown and root rot of orchardgrass. Preliminary studies have indicated a correlation between the development of the disease in S-37 orchardgrass, and the susceptibility of this variety to winter freezing injury. Further study of this finding is being conducted by means of an experiment designed to combine winter freezing injury with plant exposure to Rhizoctonia solani and Fusarium roseum.

Title: DISEASES OF RED CLOVER

Leader: H. B. Couch

Utilizing information from the previous year's studies concerning cultural variation, as well as the distinctiveness of the numerical threshold of infection of Kabatiella caulivora, isolates of the organism from Pennsylvania and New Hampshire were used in greenhouse inoculations of plants of the variety Pennscott, and selections for various levels of resistance were made. In addition, individual plants of the northern anthracnose resistant Wisconsin Polycross were screened for degrees of resistance to the Pennsylvania and New Hampshire isolates.

Plants showing a very high level of resistance and extreme susceptibility to K. caulivora were selected. Those of the former group are being used for introduction of resistance to northern anthracnose into the variety Pennscott.

Basic investigations concerning the cultural behavior of K. caulivora were continued. These were aimed primarily at refinement of a technique for continuous replenishment of solutions under aseptic conditions. Using peristaltic pumps and specially designed culture flasks, a system has been developed that allows the growth of the organism in culture indefinitely in its initial conidial, highly pathogenic, form.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL (LOTUS CORNICULATUS L.)

Leaders: R. W. Cleveland and J. L. Starling

A broadcast plot variety trial at Ligonier, Pa., was harvested for the second year for forage yield. Yields of Mansfield, Cascade, Viking and Imported trefoils were highest and were non-significantly different. Empire yielded less than the beforementioned varieties.

Other variety trials and breeding evaluation trials at various locations in Pennsylvania were severely injured by ice-sheet damage during the winter of 1958-59 and could not be harvested, or in some cases had to be abandoned.

Surviving plants from several ice-sheet damaged plantings (including variety trials and progeny evaluation trials) were collected and established in a new spaced planting. These plants and their progenies will be evaluated as possibly more winter-hardy than the average of the stocks from which they were derived.

Seed production nurseries of four experimental synthetics (formulated in 1956) are being maintained for the preservation of the genetic material. The evaluation of these synthetics is not yet complete.

A uniform disease nursery was established with colonial material supplied by Dr. Paul Henson (A.R.S., U.S.D.A.). This is a cooperative program including several experiment stations and ARS to evaluate breeding materials for disease resistance.

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.)

Leaders: R. W. Cleveland and J. L. Starling

Six alfalfa variety trials located near University Park and four out-state locations in Pennsylvania were harvested for forage yield in 1959. The out-state locations were Landisville, Troy, Ligonier, and Tunkhannock. Vernal, DuPuits and Narragansett alfalfa are the top yielding varieties in most trials. Some of the newer varieties and experimentals such as Alfa, NY-B, and NY-A appear very promising.

An experiment designed to give an evaluation of alfalfa varieties grown in association with certain experimental grass varieties under two management systems is in progress. The test involves the following comparisons:

I Grass + Nitrogen (3 + 4 cut mgmt.)
II Grass + DuPuits Alfalfa (3 + 4 cut mgmt.)
III Grass + Grass + Vernal alfalfa (3 cut mgmt.)
Grass + Narragansett alfalfa + Ladino clover (4 cut mgmt.)

Overall managements, cuts, years and locations the following ranking for total yield was obtained:

1. Grass + DuPuits
2. Grass + legume (Vernal or Narragansett and Ladino)
3. Grass + N.

This ranking among associations is not significant principally because of significant interactions between associations, managements and locations.

Two new alfalfa broadcast plot experiments were established in 1959. These include one variety and blend test and one trial to measure the performance of variety blends of different proportions and under different seeding rates. These trials will be harvested for the first year in 1960.

None of the available creeping varieties has been found to be highly adapted under Pennsylvania conditions. Plants were selected on the basis of number and width of spread of shoots from creeping roots in September from a spaced plant nursery on the Agronomy farm at Centre Hall, Pa. The plants were selfed in the greenhouse in November. Approximately 22 of the original 35 plants yielded about 50 seeds each.

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: R. W. Cleveland and J. L. Starling

Broadcast plot variety trials at three out-state locations were harvested for forage yield in 1959. Pennscott red clover continues to be the best variety in regard to consistently high forage yield at most locations in Pennsylvania. The newer variety Chesapeake (of Maryland origin) is a very good yielder at most locations, but the Wisconsin release "Lakeland" has a lesser yield potential in Pennsylvania.

The breeding program to incorporate resistance to northern anthracnose (Kabatiella caulivora) into Pennscott red clover was continued in 1959. Resistant plants were selected from Wisconsin synthetic (Lakeland) in 1958. An F_1 was made between resistant plants and about 50 Pennscott plants. The first backcross generation will be made as soon as the F_1's produce flowers.

A study to determine the inheritance of resistance to northern anthracnose has been initiated. Resistant and susceptible plants have been established in the greenhouse for this purpose. Intercrosses have been made among the resistant plants to determine their genetic constitution with regard to anthracnose resistance.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: J. L. Starling, R. W. Cleveland, and H. R. Fortmann

Third-year results were obtained on the polycross progeny of 136 clones selected in 1952. Yield, maturity, disease reaction data were collected. Results of the three years' testing have been summarized, and the superior clones in three maturity groups will be entered into a regional evaluation program.

Second-year evaluation was made of seven experimental synthetic varieties. Results to date suggest that Pa. Medium Synthetic II may have significant yield superiority to check varieties under high nitrogen fertilization.

First-year yields and performance data were collected on three restricted polycross progeny trials representing early, medium and late maturity groups. Progenies being tested are those of clones included in all experimental synthetics currently in the orchardgrass breeding program. The results of these tests will be used in evaluating the synthetics and in reformulating the synthetics.

Nine nurseries (for the production of synthetic varieties) were maintained and seed was harvested from three.

The Pennlate breeders seed nursery was maintained. Winter injury occurred in 1959, therefore, no seed was produced.

A 2500-plant spaced plant nursery was established from the progeny of 33 better clones in the current breeding program. Second and Third cycle evaluation will be made on these clones and their progenies.

A replicated row planting was established to study the consistency of the performance of the synthetic variety, Pennlate, over several synthetic generations. Seed from a foundation planting in California is being compared with locally produced foundation and breeders seed. The test also includes restricted polycross progeny of each of the four clones and all possible two and three clone combinations of the progeny of the four parental clones.

Title: INSECT PESTS OF FORAGE CROPS

Leader: N. D. Blackburn

Research efforts were concentrated on the alfalfa weevil which continues its spread throughout the state. The insect now occurs in 48 of the 66 counties.

Egg deposition and subsequent egg development were again prolonged by unfavorable temperatures during the spring of 1959. As pointed out in a previous report, this retardation of development complicates the application of control measures against the larval population. One is unable to establish the exact point when treatments should be applied to control the larvae already present in the field at the time as well as to maintain sufficient residual toxicity to control those hatching later.

Experiments on control of the alfalfa weevil during 1959 were designed to compare the relative effectiveness of the various materials applied early in the season before significant plant growth had occurred. It was anticipated that clearance for the use of heptachlor on alfalfa might be withdrawn in the near future because of the occurrence and apparent persistence of a toxic degradation product, heptachlor epoxide. Such an action would seriously limit the materials available for control of the alfalfa weevil. Consequently, an effort was made to find a possible substitute if such an eventuality should occur.

Granulated and emulsifiable formulations of heptachlor were both applied at the rates of 0.75, 1.0, and 1.5 pounds per acre in early-season, replicated treatments in southern Pennsylvania. Thimet (granulated) at the rate of four pounds per acre and dimethoate emulsifiable at the rate of 1 pound per acre and granules at the rate of two pounds per acre were applied in plots in the same experimental design to compare their relative effectiveness with heptachlor.

Records on larval populations taken at three intervals between treatment and harvest showed a control level of approximately 96% with the intermediate rate of heptachlor, a zero control level with Thimet (4 times the application rate of heptachlor), and approximately 20% control for each of the two formulations of dimethoate.

Data on aphid populations taken at the same three intervals noted above showed a significant reduction in plots treated with Thimet and dimethoate. The reduction in population levels ranged from 60-70% with dimethoate being slightly more effective. As in experiments during previous seasons, heptachlor produced no depressing effect on the aphid population.

Preliminary laboratory experiments to establish dosage-mortality curves with various materials for alfalfa weevil adults indicated dieldrin to be quite similar to heptachlor. Previous field experiments have shown the latter material to be more toxic. If dieldrin could be used at a lower rate in early-season treatments when subsequent residues could possibly be avoided, it might provide an adequate substitute for heptachlor.

RHODE ISLAND

Title: NITROGEN FERTILIZERS FOR GRASS AND GRASS-LEGUME MIXTURES

Leaders: R. C. Wakefield, J. W. Cobble, and J. B. Smith

Plots of S-37 orchardgrass and Lincoln bromegrass were fertilized with two sources of nitrogen at three times and three rates for the third year (1958 Annual Report, page 127).

Data for the three-year period indicated the importance of adequate nitrogen in the spring to take full advantage of the potential yield due to usually favorable moisture conditions, temperature and the physiological condition of the plant. Applications of 150 pounds per acre gave best results for the first growth. Subsequent applications of 50-75 pounds gave good aftermath growth. Larger applications of nitrogen at either time resulted in small yield increases for the species tested.

Orchardgrass was more responsive than bromegrass to equivalent nitrogen applications. Ammonium nitrate was again superior to ureaform.

In grazing trials, nitrogen-fertilized orchardgrass resulted in greater yields of forage, greater animal consumption but lower weight gains than orchardgrass-Ladino clover.

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leader: R. C. Wakefield

Yield data from the 1958 herbicide experiment (1958 Annual Report, page 128) revealed that treatments were generally not significantly different during the second year. Severe winter injury by heaving reduced alfalfa and birdsfoot trefoil stands regardless of previous treatments.

Additional experiments were established during 1958. Best results were obtained with Neburon (pre-emergence 2 lbs./A), 4 (2,4-DB) plus dalapon (post emergence 1½ lbs./A plus 2 lbs./A) and EPTC (incorporated 3 lbs./A). Results were based on yields of weed-free forage, stand counts, root weight per plant and tillers per plant.

Title: BREEDING AND EVALUATING ALFALFA FOR EASTERN UNITED STATES

Leaders: T. E. Odland and R. C. Wakefield

The breeder seed plot of Narragansett alfalfa is being maintained. Additional cuttings were made, plants started from these in the greenhouse and established plants added to the breeder seed population. The 1959 season like the one in 1958 was very unfavorable for alfalfa seed setting. Only about 2 pounds of usable seed was obtained. The supply of breeders seed of this variety has reached a very critical stage and a favorable season for seed setting is urgently needed.

Title: EFFECT OF NEMATOCIDES ON YIELD OF ALFALFA

Leader: G. J. Stessel

In pre-planting fumigation field trials for the control of the root lesion nematode Pratylenchus pratensis (de Man, 1880), Filipjev, 1936 on Narragansett alfalfa in Rhode Island, 1,2-dibromo-3-chloropropane at 1.25 gal./acre showed a 17 percent alfalfa yield increase over the control in 2-year stands in 1959. Fumigation brought about a 77 percent reduction in nematode numbers in 1957. Both treated and untreated plots showed high incidence of crown rot (80-90 percent) in 1959. Effectiveness of the nematocide was probably limited because plots contained newly plowed under 6-year old alfalfa roots at the time of fumigation.

Title: GRASS-LEGUME SILAGE AS THE SOLE FORAGE FOR FEEDING DAIRY CATTLE DURING THE SUMMER

Leaders: B. W. Henderson, Jr., J. W. Cobble, R. G. Lundgren, J. B. Smith, R. C. Wakefield, and N. Rorholm

A comparison was made between grass-legume silage and soilage as the sole forage for 24 lactating dairy cows during the summer season. The cows were paired in relation to breed, age, size, and production of 4% Fat-Corrected Milk. The average FCM production was 36.0 and 41.1 pounds, respectively for the silage and soilage groups. Daily dry matter intake was 21.0 pounds for the silage group and 30.4 pounds for the soilage group. Body weights for the two groups were not significantly different.

VERMONT

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: George B. MacCollom

Studies on the timing of applications for control of injurious insects on birdsfoot trefoil were conducted in 1959. Toxaphene at 1.5 pounds actual per acre was applied in May when the accumulative degree days (using a 40° base) reached 350, 380 and 410, respectively. No significant differences between treatment dates were obtained. Additional studies on a pre-bloom application showed no significant increase in yield, providing an earlier application had been made.

Title: WHEY AS A FERTILIZER FOR PASTURE GRASSES

Leaders: R. N. Morehouse and A. R. Midgley

Due to the stream pollution problem presented by the large quantities of cheese whey produced in Vermont, new methods of utilization and disposal are being sought. Whey sprayed on to permanent pasture showed an increase in yields and quality of forage. In one case whey treated grass yielded 13.5 tons of green forage testing 23% protein compared to that of one ton of forage testing 7% protein on untreated areas. Grasses respond more readily than legumes to amounts up to one acre inch. Rates exceeding this cause excessive lodging and difficulties in harvesting. Very heavy rates during a short

period of time are likely to kill existing vegetation. About two weeks are needed after whey is applied before the nutrients become available to plants. Whey could be used to advantage by many farmers; however, its bulky nature limits its use to areas close by cheese factories.

Title: THE USE OF BIRDSFOOT TREFOIL MEAL AS A CONSTITUENT OF POULTRY RATIONS

Leaders: G. M. Wood and W. D. Bolton

As a follow-up to feeding trials with poultry (1958 Annual Report, page 132) the estrogenic activity of trefoil in comparison with alfalfa will be studied. Plans call for the injection of young female rats with estrogenic extracts from birdsfoot trefoil and alfalfa.

Title: EFFECT OF SIMULATED PASTURE MANAGEMENT PRACTICES ON THE PERSISTENCE, QUALITY, AND YIELD OF SEVERAL BIRDSFOOT TREFOIL SPECIES AND VARIETIES

Leaders: G. M. Wood and K. E. Varney

Severe winter killing occurred during 1958-59 under all treatments (see 1957 Annual Report, page 98, for description of treatments, also 1958 Annual Report, page 132). Because of tremendous variation in survival between plots no significant differences for varieties or treatments were obtained. Significant survival differences between replicates (randomize block design) were obtained, however.

Title: AGRONOMIC EVALUATION OF NEW EXPERIMENTAL LINES AND HYBRIDS OF BIRDSFOOT TREFOIL

Leaders: T. R. Flanagan and F. Laing

(A) Continued selection of hybrid trefoil entries (1958 Annual Report, page 131) was hampered by a severe drought during 1959.

A sixth cycle of selection of these hybrids of L. corniculatus and L. tenuis 4X will be completed this year. In addition, progeny tests for yield will be continued and a new one-acre plot will be seeded this spring.

(B) The selections from the 1957 L. tenuis 4X polycross nursery which were located on heavy soil last year will be observed for another season because of the drought period last year.

WEST VIRGINIA

Title: A STUDY OF NUTRITION, SOIL, AND HERBAGE INTERRELATIONSHIPS IN A SYNDROME RESEMBLING HYPOMAGNESIUM TETANY IN RUMINANTS

Leaders: D. J. Horvath, G. C. Anderson and N. M. Baughman

Prevention procedures are being evaluated under field conditions and experiments are being conducted to produce the syndrome in cattle and sheep. Limited evidence strongly suggests that the syndrome "Grass Tetany" or "Winter Tetany" can be prevented by increasing the energy intake of cattle and by supplying additional magnesium as a part of a high energy supplement to the roughage ration. Epsom salts are being used as the source of supplementary magnesium. Present data do not permit the formulation of definite recommendations but it is believed that the following major factors are to be considered.

(1) Maintain adequate digestible energy intake. A cereal grain and/or a high protein supplement are suggested with a level of feeding from one to two pounds per head per day depending upon the quality and amount of hay fed. The compositions of a suggested supplement would be as follows:

1,000 lbs. soybean oil meal
1,000 lbs. corn and cob meal
250 lbs. feed grade Epsom salts

This should provide about 3 ounces of Epsom salt per cow per day and should be fed for at least one month before calving.

(2) Dolomitic limestone should be used if available.

(3) The incidence of the syndrome seems to be closely related to temperature changes. Available information suggests that cases will very often occur if a marked drop in temperatures is experienced after four or five consecutive warm spring days.

(4) Cattle should be turned to pasture gradually and every effort made to maintain a satisfactory energy intake.

(5) English workers suggest that applications of N and K be delayed until after May 15.

Title: USING NITROGEN FERTILIZER EFFICIENTLY

Leaders: E. M. Jencks and G. G. Pohlman

Nitrogen as ammonium nitrate containing lime was applied at the rates of 60, 120, 240 and 360 pounds per acre on Kentucky bluegrass in April, June and August and in April and June. Pasture conditions were simulated by clipping the forage with a reel-type lawn mower when the grass grew to a height of four inches.

All treatments, except the August treatments, produced considerable dry yield increases. The highest total yields resulted from 120 pounds of ammonium nitrate applied in April and again in June. This increase amounted to 92% as compared to the controls. In general, the April and April-June treatments produced the greatest yield increases. June treatments were less effective, but were more effective than August treatments. Yields from all treatments were greatly reduced because of drought during July. However, the drought effect was considerably modified by the 240 and 360 pound treatments applied in April, and by the 240 and 360 pound per acre ammonium nitrate treatments applied in April and June. In these instances, yields were more than doubled.

Title: THE PERFORMANCE OF SEVERAL ALFALFA VARIETIES GROWN UNDER DIFFERENT CLIMATIC CONDITIONS, WITH EMPHASIS ON THE INFLUENCE OF FALL CUTTING

Leaders: G. A. Jung and W. T. Carlson

Eight locations were chosen for testing six alfalfa varieties for persistence and relative performance under a wide range of climatic conditions found within West Virginia. At the same time, an attempt was made to select locations which would provide information on the effect of elevation, latitude, and the length of growing season on the performance of the varieties.

Four fall cutting dates were selected to study the effect of time of fall cutting at each location.

Title: ZERO GRAZING VERSUS FIELD GRAZING AS SUPPLEMENTAL FORAGES FOR ANIMALS ON PERMANENT PASTURE

Leaders: R. A. Ackerman, R. G. Mitchell, C. H. Taylor - Department of Dairy Husbandry; K. C. Elliott - Department of Agricultural Engineering; G. A. Jung - Department of Agronomy and Genetics

A considerable amount of land in West Virginia is in permanent pasture which furnishes sufficient forage during the early part of the growing season but becomes unproductive during late June, July and August. Because of the limited forage production during the dry summer months, some type of supplemental feeding is necessary. Since hay for winter feeding is limited, it is important that maximum use be made of this forage. This study was initiated to study the economics of forage production and the performance of cows under both "zero grazing" and "field grazing" for supplemental feed.

Twenty Holstein cows were divided into two groups as equally as practicable as to productive ability, age, weight and calving date. The cows were pastured on permanent pasture until forage became limiting and then were given supplemental feed. One group of cows field grazed while the other group zero grazed twice a day for 45 minute periods. The data for the first year are being analyzed.

Title: INSECT CONTROL IN FORAGES

Leaders: C. K. Dorsey - Department of Entomology; and G. A. Jung - Department of Agronomy

This study was initiated to determine the effect that certain insect populations have on forage quality. Four insecticides were applied to an alfalfa-orchardgrass stand and insect counts and forage samples were taken at regular intervals in the treated and non-treated areas.

The insect counts indicate that each insecticide controlled different insect populations. Quantitative determinations are being made on the forage samples to measure the quality of the hay from the treated and non-treated areas.

USEFUL TECHNIQUES

U. S. REGIONAL PASTURE RESEARCH LABORATORY

The Determination of Ether Extract on Air-Dry Forage

The determination of ether extract (or crude fat) is a common one in the analysis of feeds and forages. The official method calls for the extraction of each sample individually in a small Soxhlet, a procedure which ties up a lot of equipment and space. The ether extract then may be evaporated to dryness and the residue weighed and it is difficult to get consistent weight. A procedure which overcomes these difficulties has been used successfully. Place a weighed quantity, 1-2 grams, of sample in a weighing dish with cover and dry 5-15 hours in a vacuum oven at 70° C. Cool and weigh. The loss in weight is moisture which can be recorded if this is also desired. Transfer the sample to a sheet of filter paper, Whatman #2, 11 cm., fold tightly, wrap and tie with thread. Pack a number of these in the extraction tube of an all-glass Soxhlet apparatus, the large size holds about 20 samples, and as they will have picked up moisture again, place the tube containing the samples in the vacuum oven and again dry. Turn off the heat and allow to partially cool before turning off the vacuum and opening the oven (for ease of handling). Quickly assemble the Soxhlet apparatus. In the meantime have placed 1 pound of anhydrous ethyl ether, from a sealed one-pound can, in the 1000 ml. flask of the extractor. Protect the top of the condenser from moist air by a drying tube. Conduct the extraction overnight at a low heat. Cool, remove the fat-free samples, allow to air dry, transfer back to the same weighing dishes, and again dry. Cool and weigh. The loss in weight since the last weighing is ether extract. This determination should not be made in humid weather.

Measurement of Height of Grass in a Plot

To measure the average height of grass in a plot may be a time-consuming chore. When different species of grass were grown in pure stands in small plots for chemical composition studies it was of interest to know the relative height before each cutting. A piece of stiff corrugated paper, 2 feet square, weighing about one-half pound, was dropped gently and horizontally on the plot. The longer stalks bent under the weight and the paper came to rest at a certain height which was reproducible as determined by repeated tests. The height from the ground was measured with a rule at the center of each of the four sides and averaged to the nearest one-half inch. This method has been used only on plots cut before heading or at aftermath.

NEW JERSEY

An Apparatus to Facilitate Flame Photometer Operations

It is not uncommon for agronomists to analyze forage or soil samples for their mineral content by the hundreds. When using the type of flame photometer which requires that samples or standards be poured into a small funnel the frequent pouring of standard solutions into the small funnel of a flame photometer for wave-length selection and setting of the machine, as well as periodic checking against standards, contributes to operator fatigue. Accidental spilling of solutions, over-filling the funnel, gross fluctuations in the level of solution in the funnel are annoying inconveniences which contribute to reduced operator efficiency. These difficulties are largely overcome by the use of a siphon apparatus and large reservoirs. Less time is required to make one large quantity of standard solution, such as contained in the large reservoirs, than an equal volume made in several increments on separate occasions.

A box-like frame may be placed on top of the flame photometer to support the large reservoirs and to provide attachment for a side-arm. The side-arm supports screw-adjusting clamps which regulate the flow of the standard solutions into the funnel. The glass-tipped tubings of the siphon systems, which conduct the internal standard and the element being determined, are positioned over the funnel. The funnel can be filled quickly and then maintained at a relatively constant level, when needed, by adjusting the screw-clamp. A filter pump is convenient for quick emptying of the funnel of standard or unknown solutions.

VERMONT

Procedure for Separation of Chicken Crop Contents

For researchers interested in studying forage consumption by poultry the following technique has been developed.

Each crop is placed in a half-pint waxed milk carton with the identifying leg band. The cartons are then stored in a refrigerator, or in a freezer at 0° F. if separations are to be delayed. Crops can be stored several months when frozen and may be thawed and refrozen if necessary. Fresh condition is maintained despite freezing. When the separations are to be made the crops should be thawed sufficiently to remove the contents. This may be accomplished by soaking the crops a few minutes in warm water. An examination of the crop contents is then made and forage species identified. If photographs are to be taken to illustrate the kinds of forage present, separation in the fresh

condition is desirable. (This is a slower, less accurate and more tedious procedure.) Otherwise the whole crop contents are placed in a forced draft oven and dried overnight at 200° F. After recording the total dry weight in grams the dried crop contents are placed in a white porcelain casserole ($8\frac{1}{2}$" in diameter by $2\frac{1}{2}$" deep) or other suitable container filled with water. A wetting agent is then added to facilitate separation of the mash (or pellets) from the grain. After the crop contents have been completely wetted the casserole is emptied on to a U. S. Standard sieve (screen) of .0469 inch openings (1190 microns). Other small mesh sieves may also be satisfactory. Using a broad rapid stream of water the mash is then washed out through the sieve. The remaining material is carefully washed back into the casserole which is again filled with water. Forages, feathers, and other light materials will float on the surface and can be picked off with blunt tweezers or removed by carefully decanting the water back through the sieve. The heavier grain and grit will remain on the bottom of the casserole. Each component is then identified, labeled, and placed in the oven in separate containers for redrying. Unwaxed paper cups make satisfactory containers. After the materials are again dry, weights are recorded in grams (to the nearest tenth) for calculating the percentage of each component. Mash content is determined by subtracting the sum of all remaining fractions from the total dry weight of the original crop contents. (For results obtained by using this technique see Poultry Science 35:1083-1089. 1956; and Official Report 11th World's Poultry Congress, 1958.)

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